# ORTHOPEDIC SURGERY

THORNDIKE

# A MANUAL

# OF

# ORTHOPEDIC SURGERY

BY

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TO

MY COLLEAGUES PAST AND

PRESENT AT THE CHILDREN'S

HOSPITAL AND ESPECIALLY

TO

MY TEACHERS AND FRIENDS,

E. H. Bradford, M.D.

AND

R. W. Lovett, M.D.,

IN GRATEFUL ACKNOWLEDGMENT

OF THEIR KINDNESS AND PATIENCE,

THIS BOOK IS DEDICATED.

# PREFACE

In this little book the attempt is made to present Orthopedic Surgery in a simple way to the student and practitioner by re-arranging the subject so that the deformities which fall to the orthopedist are grouped both etiologically and chronologically. Part I comprises the ante-natal deformities, errors of development of the skeleton or of the nervous system, fetal bone diseases, accidents of birth like obstetrical paralysis or intracranial hemorrhage with spastic paralysis: Part II, deformities due to the action of external forces on growth, like weight-bearing, improper restraint from clothing, unequal or asymmetrical muscular development as in flat-foot: Part III, the diseases and injuries of the bones and joints excepting those of the fetus: Part IV, deformities from acquired diseases of the nervous and muscular systems: Part V is a technical description of the use of plaster-of-Paris, and of the way to make, fit and use some of the orthopedic appliances in vogue in this vicinity. While freely admitting the impossibility of an absolute classification of this sort because there are many deformities like coxa vara which arise from diverse causes, it is earnestly hoped that the student may be saved from confusing in his mind the identity of things essentially dissimilar like spondylitis and scoliosis, or congenital and acquired club-foot.

The writer desires to express his thanks to his colleagues and others who have helped him, especially to Professors Dwight and Bradford, of the Harvard Medical School, to Dr. Schulthess, of Zurich, whose exhaustive article on Scoliosis in Joachimsthals Handbuch der Orthopædischen Chirurgie has been freely used, and to Dr. Max Böhm now of Berlin, likewise to Dr. R. W. Lovett, from whose book on Lateral Curvature a chapter is borrowed; and for aid in illustrating to Dr. A. W. George, radiographer to the Children's Hospital and of the Department of Anatomy.

AUGUSTUS THORNDIKE.

*Boston, Massachusetts,*
*September*, 1907.

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# ORTHOPEDIC SURGERY.

## CHAPTER I.

### MALFORMATIONS OF THE LIMBS.

Congenital human deformities are so various that the author cannot here describe all of the varieties; selected examples must suffice instead of a detailed complete list. The student must not be surprised to meet at the clinic congenital deformities which are not described here, but should store in his mind, from his study of the examples, certain typical classes into which malformations fall and from which they may vary. He should strive by careful observation to study each individual case so as to recognize the true nature of the deformity and to evolve independently of his teacher something to restore the function of the limb or lessen the disability.

Many congenital deformities shorten life to a few days or weeks or are found in the still-born, such as anencephalus, rachischisis, etc.; others, like spina bifida, are often curable; the latter is considered in works on general surgery and is therefore omitted.

#### TOTAL DEFECTS.

Absence or extensive malformation of the extremities is not fatal but is very disabling for when both the arms and legs are lacking it is obviously impossible to supply the deficiency. A total deficiency of all four members occurs but rarely and produces great helplessness. The term ectromelian designates a person with complete absence of one or more limbs; hemimelian, one without the terminal portion of a limb or limbs, without hand or foot; phocomelian, one whose much shortened limb bears a hand or foot close to the trunk like the flipper of a seal. These are the result either

of lack of development, or of amputation *in utero;* only the phocomelian necessarily represents lack of growth, the other two may arise either because they failed to form or because they grew and were cut off. Non-formation of a limb must be due to some process beginning before the fourth week of embryonic existence, for the limbs appear about that time. Congenital amputations are of later origin—the earliest one recorded showed the remains of a foot corresponding to that of a ten weeks fetus. A limb is amputated either by tight encircling coils of umbilical cord or by so-called amniotic bands forming a constriction around it. An amniotic band is a string-like structure connecting the skin of the fetus with a point on the amniotic lining of the fetal membranes. When these bands are present at birth, some sort of congenital malformation is generally present.

FIG. 1.—Fetus with congenital amputations. (Cast in the *Warren Museum.*)

### ABSENCE OF ONE PAIR OF EXTREMITIES.

When one pair of limbs is absent, the helplessness is less; absence of both legs may give rise to but little inactivity, for artificial limbs or any serviceable rigid support may be used with crutches, and little ones soon learn to walk on their hands.

Absence of the arms is more disabling, but one often finds useful fingers or a partly formed hand near the shoulder as in the accompanying photograph. (Fig. 3.) This boy, with his fingers, could write with pencil or pen and do a variety of things which he learned at the public school; he also learned at the Industrial School for Cripples to typewrite with his toes, to draw on the blackboard with them, and to use his feet for hands in many ways.

In Denmark, Norway and Finland, special schools for cripples exist where ingenious machines and contrivances are used to take

the place of hands. Handless cripples are taught to weave cloth, to make brushes, baskets, and shoes, using the tongue and teeth principally. Some women even embroider with the teeth and the toes may be trained to great usefulness. For many years a handless artist was seen in the art gallery at Antwerp painting pictures with his feet. Boston, New York, and Philadelphia now give industrial training to cripples.

Artificial hands and arms are made lighter and more serviceable than they used to be, but their field of usefulness is limited.

Less disabling are the deficiencies of one or more of the long bones of the limbs; these partial defects may occur in one, two, or even four extremities. For instance, a woman in Germany has the following malformations: the left upper extremity consists of an upper arm bearing a single finger; the right arm is a tapering stump, containing half of the humerus; the left leg lacks the femur and the fibula; the right is a rounded stump, containing two short bones bearing a small foot, of which the heel, sole, and two toes are present. With the help of special artificial legs and arm she can write, knit, wash, partly dress herself, and feed herself with fork, knife, and spoon; she walks easily, keeps busy and enjoys life.

FIG 2.—Fetus with absent right lower extremity. (*Warren Museum.*)

## PARTIAL DEFECTS OF THE UPPER EXTREMITY.

**Club-hand.**—Absence or defect of the radius or ulna produces club-hand, a term which designates a deviation of the hand

at the wrist from its alignment with the forearm; a lateral deviation means a congenital deficiency of the radius or ulna—the hand turns to the side of the missing or defective bone. Congenital displacements of the hand in extension or flexion may be called club-hand and this kind is not associated with bony defect, but with some other cause, such as early developed paralysis. Club-hands

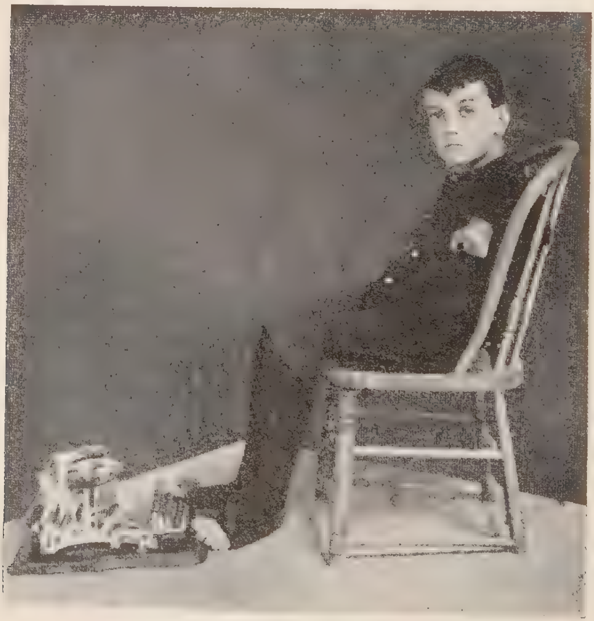

FIG. 3.—Armless boy typewriting. (*Industrial School for crippled and deformed children.*)

like club-feet have been described by adjectives, which define the direction of the malposition, such as palmar, dorsal, radial and ulnar club-hand, radio-palmar, radio-dorsal, ulno-palmar, and ulno-dorsal club-hand. Radio-palmar is the common type, with the ulna usually strongly bowed inward and the hand pointing at right angles to or somewhat up the arm. Deficiency of the ulna is rare,

and all elbow motion is lost if the ulna be absent; only part of the carpus is developed and the little and fourth fingers are often lacking. One finds the thumb missing with most defects of the radius. The changes in the articular facets and the formation of the wrist bones are analogous to those in congenital club-foot. Kirmisson describes curious anomalies of the muscles of the forearm.

**Treatment.**—Mild club-hands, especially in little babies, are treated by gentle manipulations, bandaging to a light splint, or the child is etherized, and the hand held by a plaster bandage in an

FIG. 4.—Cast of radiopalmar club hand. (*Warren Museum.*)

overcorrected position gained after forcible stretching. One treated this way for a year, at the Children's Hospital, had the hand firmly grown into a normal position at the end of that time. A small tin splint was used six months longer as a precaution. Three years later, the child had a good, straight, useful hand. In older children, whenever the difficulty of reduction demands it, tenotomies or tendon

transferences may be tried, or shortening and lengthening of certain tendons. When there is only one bone in the lower forearm, especially if it be crooked, osteotomy and retention for a long time in a plaster bandage has given excellent results in a few cases. The after treatment demands careful muscle training and massage. The following bone operations have been performed on rebellious cases: cuneiform osteotomy of the ulna, by Thompson; suture to the semilunar bone of the split styloid process of the ulna, by McCurdy;

FIG. 5.—Bones of same. (*Warren Museum.*)

the removal of two carpal bones and fastening the end of the ulna into the hole in the middle of the wrist, by Sayre; wedging the carpus into the split open end of the ulna, by Bardenheur; Kirmisson aims at a stiff wrist, for he regards instability of the hand after operation as the most serious obstacle to its utility. Operations for muscle transference have been little tried so far.

## PARTIAL DEFECTS OF THE LOWER EXTREMITIES.

**The femur** is far more often defective than absent. According to Reiner, there may be (1) a congenital coxa vara with the shaft and the femoral neck short and crooked; or (2) the femur may be divided into two different parts, the head and trochanters forming the upper portion, while the distal end articulates both with it and with a fairly normal knee-joint; or (3) in extreme cases, only the head, neck and trochanters exist with a small remnant of the distal end of the femur growing on top of the tibia without knee-joint. Reiner considers all these conditions are due to the same sort of maldevelopment. The modelling action of the muscles determines the amount of crookedness of the femur. These deformities of the femur are often associated with absence of the fibula, the patella, or part of the foot, and produce much shortening of the leg.

FIG. 6.—Absent or tardy Patella.

A young woman who has been under the writer's care for several years with a shortened leg of this sort, walks with ease, using an artificial limb designed by Gibney, of New York, which takes advantage of the flexed position of her hip and knee and offers a broad shelf on which the under surface of the thigh rests and the body-weight is supported. She is better off with this apparatus than she would be with an amputation stump and an ordinary artificial limb.

**Absence of the patella** is infrequent. In a baby, one cannot tell if the patella will form later or not; doubtless, many a case of tardy development has been reported as absence of the patella. This bone should appear as a cartilaginous deposit in the third month of fetal life, and ossification begins between the ages of four and seven years and should be completed at puberty. The defect may be double or single, and the sexes are equally affected.

Other malformations were found in half the cases in literature. Ankylosis of the knee associated with defective femur is not infrequent; general laxity of the knee may be present, or a subluxation; sometimes the tendon of the quadriceps is inserted into the joint capsule instead of into the tubercle of the tibia. Unless these malformations accompany the deformity, the prognosis for a useful limb is good. While children they fall easily and are unsteady, in later life there is little disability and the gait satisfactory. Some are easily tired, totter a little, go down stairs cautiously, fearing a fall; others are not impeded in any way.

**Treatment.**—Surgical skill cannot make a patella grow. In lax knees prevention of abnormal movements in the joint does good, for by restricting side movements, the knee ligaments in a child soon tighten and the joint regains its utility. A serviceable appliance for this purpose consists of a light double upright splint with a hinge joint at the knee so arranged as to allow less than the normal amount of flexion and extension. Where a faulty attachment of the quadriceps tendon into the joint capsule occurs (a rare condition) it might be transplanted into the tubercle of the tibia, by an operation.

**Absence or Defect of the Fibula.**—The fibula is deficient more often than the tibia but both conditions are uncommon. When this malformation exists, the foot is always displaced. It is more common for the fibula to be absent completely or for the upper part of the bone to be present. In the foot, the little toe, or the little and fourth toes may be absent with their metatarsals. The tibia is rarely straight and it may bend sharply, suggesting the so-called intra-uterine fracture. The misplaced foot rolls out in valgus, sometimes in equino-valgus, and there may be an upward displacement of the foot at the ankle—a condition which has been described as congenital dislocation of the ankle. Left without treatment, great shortening and atrophy always occur.

**Treatment.**—Treatment aims to hold the foot in a good position to walk on, either by mechanical means, by a surgical operation, or by both methods combined. The problem is not unlike that which is presented after destruction of the fibula by osteomyelitis.

Francke, of Brunswick, Germany, in order to compensate for the shortening which usually takes place after three or four years, resected the ankle-joint and fastened the os calcis to the tibia in the position of extreme equinus. He placed the articular surface of the tibia against the upper surface of the calcis behind the astragalus and refreshed the astragalus and the front of the tibia to secure bony union between them. For temporary fixation he drove a long steel nail through the sole of the foot, the os calcis and lower epiphysis of tibia, removing the nail in three weeks. The result two years afterward was excellent, and there was no tendency to valgus.

Curving of the tibia may be remedied by osteotomy, overcorrection and immobilizing in plaster. Tenotomies or muscle transferences, may prevent a return of valgus, but, so far, a mechanical support, or a valgus shoe (Chapter XXI) and a high sole have to be employed unless union is obtained between the foot and the tibia, as in Francke's case.

**Congenital Deficiencies of the Tibia.**—These are often bilateral. Myers, of New York, found 46 cases in literature, 11 of which were observed in the fetus or new-born. It is often considered hopeless to use the limb for walking, and of the reported cases 6 had been amputated. The bone was absent 43 times in 34 children; defective 22 times in 12 children. Twice as many boys as girls had the deformity, and other deformities were present in 80 percent of the cases.

**Treatment.**—Many, however, have operated to restore functional use of the limb. In little children, they have opened the knee-joint, trimmed the head of the fibula and transplanted it into the intercondyloid notch or into a hole bored in the external condyle, straightening the foot at the same operation by tenotomies. Myers did this and then he opened the ankle-joint, cut off the external malleolus, denuded the articular surface of the astragalus, and sutured the fibula firmly to its center by coarse absorbable catgut suture. He kept the foot in a moderate equinus position in plaster for six months, and allowed the boy to walk upon it in plaster eight weeks after operation. Later on, a double upright steel splint with a

waist-band and perineal straps was worn, which was jointed at the ankle, knee, and hip; the knee-joint could be straightened and fixed and had a leather knee cap. The perineal straps were soon discarded and a cork sole was added to the boot to equalize the length of the limbs. A year afterward, he walked all day, had gained muscle power, so that he could flex the knee to a right angle and straighten it perfectly.

FIG. 7.—Malformation of the foot. (*Warren Museum.*)

**Deficiencies of the Skeleton of the Foot.**—Several of these defects may come in connection with deficiencies of the tibia and fibula. The inner side is defective with a malformed tibia, the outer with the fibula. These deformities may also occur independently. Absence of a toe usually gives no trouble, but extreme defects of the foot demand mechanical support or amputation. Once in a while one sees the skeleton reduced like that in the illustration. This boy was bereft, in both feet, of all his bones except the os calcis, one metatarsal, and the phalanges of a single toe. Amputation and two artificial legs now enable him to walk and run almost as well as anybody.

## EXTRA LIMBS.

**Supernumerary Deformities.**—The occurrence of supernumerary limbs has been explained by the inclusion of part of a twin, they are rare except in the side-show of the circus. Supernumerary fingers and toes are, however, a frequent occurrence and are usually amputated early in babyhood. Their treatment and that of web fingers is found in all works on general surgery. Extra bones are sometimes formed in the wrist and ankle which have more interest for anatomists than for clinicians. With increasing use of the X-ray, they may, however, be mistaken for fractures and dislo-

cations, and it is probable that their presence alters the statics of the foot in a way not yet understood.

## CONGENITAL HYPERTROPHIES.

**Hypertrophies of Limbs or Parts of Limbs.**—One-half the body may outstrip the other (unilateral hypertrophy), or a limb may

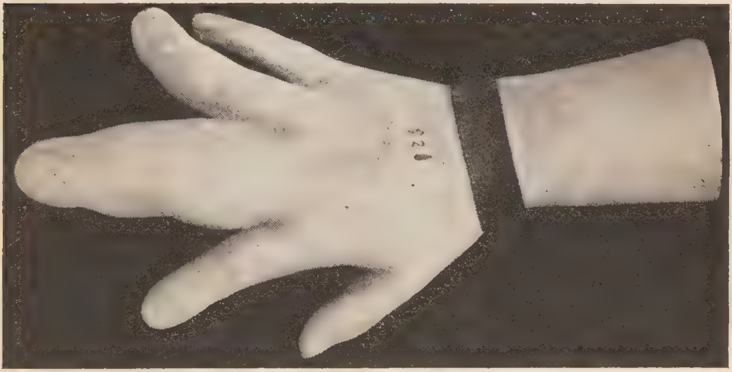

FIG. 8.—Cast of a hand showing hypertrophy of finger (*Warren Museum.*)

grow much faster than its mate, or one finger may grow as in this cast of a hand.

## CHAPTER II.

# CONGENITAL DEFORMITIES OF THE TRUNK; SPINE, PELVIS, THORAX AND SHOULDER-GIRDLE.

## THE SPINE.

Until lately malformations of the spine were limited in the minds of most student to spina bifida; other deformities were considered unimportant. If a baby had a lateral curvature it was attributed to carrying the child on one arm or to fetal rickets. Very rarely was a congenital deformity of the thorax recognized, but with the use of the X-ray malformations are now becoming more common and the occurrence of a form of congenital scoliosis is now generally conceded. Some, like Whitman, have palpated and detected the absence of a lumbar vertebra and demonstrated it by the X-ray.

**Numerical Variations in the Spine.**—Numerical variations in the different spinal regions have been attracting the attention of the anatomists: in the Warren Museum at the Harvard Medical School there is a collection of fifty-two spines showing numerical variations collected from the dissecting room by Prof. Dwight. These variations come from the persistence in the whole spine or in part of it of a greater or a smaller number of vertebræ than the number which is usual, 33 or 34, (for the embryo at one period has about 40).

The average normal spine has 7 cervical, 12 dorsal, 5 lumbar, 5 sacral and 4 or 5 coccygeal vertebræ. The occurrence of 8 cervical vertebræ is very rare, but a spine with six cervical vertebræ is not uncommon; it is also not unusual for the seventh and sometimes for the sixth cervical vetebræ to have ribs which are called cervical ribs. The development of the twelfth rib is very variable; sometimes it is rudimentary or absent, or well developed but short; at other times it is quite long; and when a cervical rib exists the thirteenth rib below is usually wanting or rudimentary and the vertebra

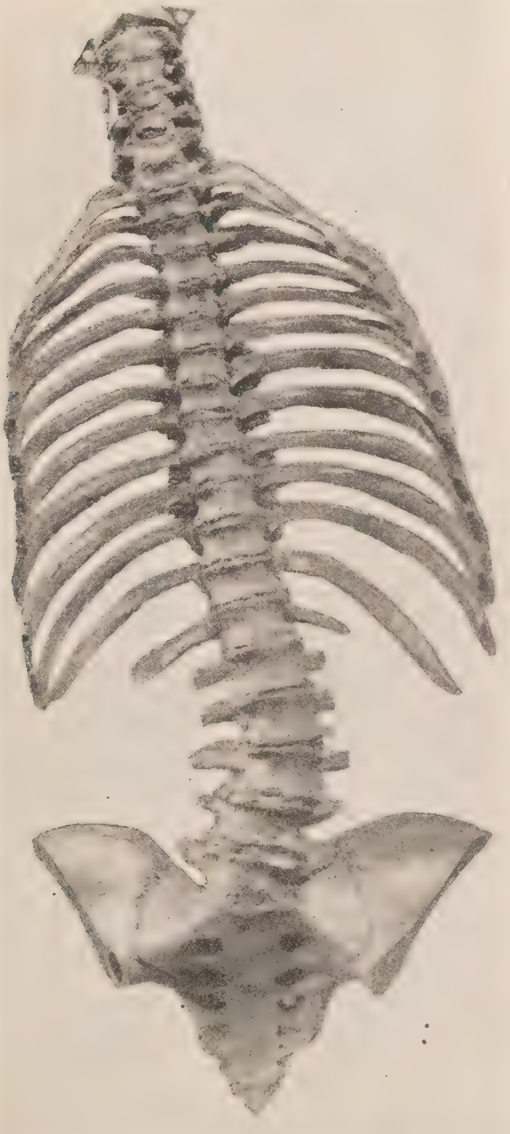

FIG. 9.—Numerical variation with scoliosis from Dwight collection, Warren
M... Thirteen pairs of ribs, that on the left is smaller and on the same side

may in shape resemble a lumbar more than a dorsal one. At other times one finds the twentieth vertebra, normally the first lumbar, with a long straight transverse process like a rib or bearing a true rib. The twenty-fifth vertebra, normally the first sacral, may be a free lumbar vertebra or it may be the second instead of the first of the sacral series. In the long and the short backs there seems to be a differing number of vertebræ and at times the pelvis and thorax may approach or get away from the head by one or two vertebræ, Böhm's variation in a cranial or caudal direction. The right and left side of the column may both be affected by this variability, or only one side may vary; and the latter seems to be a common thing to happen. Sometimes the atlas fuses with the skull on one side and behaves as a part of this variation.

**Relation of Scoliosis to Numerical Variations of the Spine.**—In what way does this spinal abnormality affect the mechanics of the spine? Do the unilateral museum specimens show any scoliotic spines among the number? Böhm found that several were evidently scoliotic, but it is possible to make any spine seem scoliotic in mounting a ligamentous specimen for the museum; therefore this should be established and verified on the living. So he had the patients with lateral curvature at the Massachusetts General Hospital Out Patient Department X-rayed.

By taking a number of small negatives of the spine and piecing the prints together he could produce a picture of the whole spine; the cervical spine was taken with the head turned to one side to get rid of the shadow of the chin. On this he could count the bodies, the transverse and spinous processes, and the ribs; for minute details of structure he studied negatives. He X-rayed all patients with lateral curvature who had no history of preceding empyema, paralysis or rickets, and of these 26 out of 31 showed evidence of numerical variation of the spine. So far this has not been confirmed or denied by the experience of others.

**Anatomical Causes of Deformity in Different Parts of the Spine.**—The mechanics of the deformity vary in different parts of the spine. The abnormal vertebræ are always on the borderline where two spinal regions join, so that one has not far to look for them. At

FIG. 10.—Kypho-scoliotic spine from the Dwight collection in the Warren Museum; with the following numerical variations, 7 cerv. vertebræ, 13 dorsal, and 6 lumbar; fusion of several vertebral bodies and of the three first ribs on the left, bicipital first ribs, the twenty-sixth vertebra is sacral on the right and lumbar on the left side; marked left lumbar-dorsal kyphoscoliosis. Note the amesial pelvis, the right side is small and the wing of the ilium flares less.

the sacro-lumbar junction one finds a vertebra which on one side is sacral and on the other lumbar, that means that one transverse process expands into a portion of the wing of the sacrum and the other is free; in these (not uncommon in museums), the top of the body always inclines and by its obliquity tips the spine out of the vertical; they resemble the wedge-shaped vertebræ of scoliosis (p. 90). At the dorso-lumbar border one may find that a vertebra has below on one side the articular process of the dorsal type and on the other side one of the lumbar type, but that they articulate with two lumbar-type joints and this tips the column above out of the vertical and inclines it to one side. At the cervico-dorsal border on one side there is a well-grown cervical rib articulating on the sternum just above the insertion of the rib from the first dorsal vertebra, which, however, is long and slender like a second rib and comes opposite to a normal short first rib on the unaffected side; the effect of two ribs of unequal length is to twist the spine by rotating the bodies of the first dorsal and last cervical away from the side of the long rib producing both a twist and a lateral curve.

These variations have been studied by Dwight and Böhm on the spines in the museum and have been demonstrated in the X-rays. All of the patients, however, developed no perceptible curve before puberty, so that, granting that they are in origin abnormalities of development, the subsequent growth of the spine must play an important share in their production.

**Congenital Scoliosis.**—The study of congenital scoliosis is receiving more and more attention the world over. Schulthess, who has just compiled for the "Handlurch der Orthopädischen Chirurgie of Joachimsthal" the most complete account of all forms of lateral curvature, says, "of late years examples of it have become so common in medical literature that one can no longer regard congenital scoliosis as a rarity, and we believe that when the cases of scoliosis receive a more careful anatomical examination, a large proportion will be transferred to the category of the congenital class." He refers to the presence of a half sacral lumbar vertebra, and to the occurrence of scoliosis with cervical ribs, with congenital elevation of the scapula, both single and double, and to its occurrence with

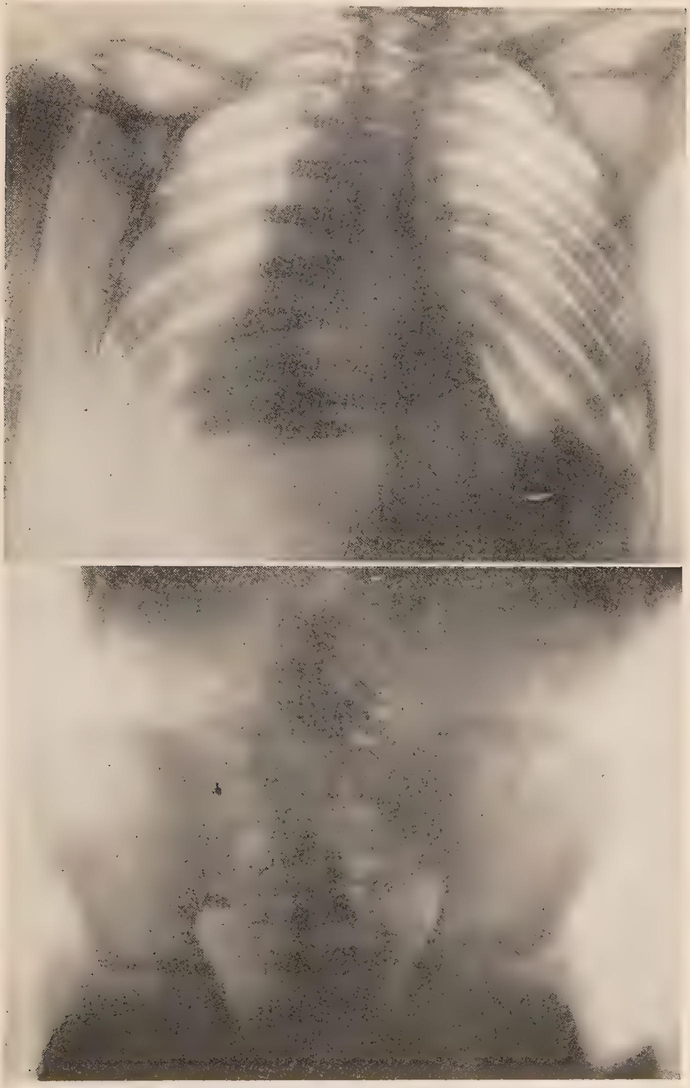

FIG. 11.—Scoliosis, on top of the sacrum is apparently a half vertebra possibly an extreme wedge-vertebra, center of column obscured by heart and liver. (*Children's Hospital, A. W. George, Radiographer.*)

spina bifida. Athanassow collected thirty-one cases of presumably congenital scoliosis, partly from his own observations, partly from literature. Schulthess also refers to two patients with congenital kyphosis and to one described by Bernhard, a baby born with a kyphos from the second to the seventh dorsal which later developed into a lateral curvature with marked rotary deformity. He divides congenital scoliosis into two groups, those which develop about puberty and those whose deformity is seen soon after birth.

Drehmann, at the Congress of the German Society for Orthopedic Surgery, in 1906, showed the X-rays of the dorsal and lower cervical spine of seven patients with cervical ribs and scoliosis, in which he could trace many curious defects, not only in the vertebral bodies which were often partly split in the median line, (an anterior spina bifida deformity), and sometimes consisted only of a rudimentary half vertebra, but also in the ribs which were often fused together for part of their length. The illustration (Fig. 11) shows either an extreme wedge-vertebra or a half-body of a lumbar vertebra in a boy with congenital scoliosis at the Children's Hospital.

The appearance of children with cervical ribs varies, some show little abnormality and a slight lateral curve of the spine, others are considerably deformed.

## PELVIS.

**Congenital Deformities of the Pelvis.**—They often are due to the sacrum which is malformed in much the same way at other vertebræ are in congenital scoliosis, and produces a deformity known as the oblique pelvis of lateral curvature. It has been studied by obstetricians as it is considerable of an obstacle to the birth of a child. As one looks down on such a pelvis one sacral wing seems much larger than the other and the oblique diameters of the pelvis are quite unequal. Sometimes the right or the left half of the pelvis grows larger than the other side and we then have the amesial pelvis.

## THORAX.

**Congenital Deformities of the Thorax.**—The congenital scoliosis which is seen in infants is often associated with malformations of

the ribs, the fused ribs, the two headed ribs, the defective or absent ribs. All these may be present, and at times the thorax is much deformed, while at other times the deformity is only appreciated after an X-ray has shown its existence. (Figures 12, 13 and 14.)

**Treatment.**—The treatment of these deformities of the spine, thorax and pelvis offers little hope of amelioration. The pro-

FIG. 12.—Congenital deformity of thorax, scoliosis, Sprengel's deformity of scapula. (*Children's Hospital.*)

FIG. 13.—Same child as in Fig. 12. Absent ribs produce the furrow below left nipple.

longed use of braces is of value, because by them the deformity is prevented from increasing and the general attitude and carriage of the child improves with time and growth sometimes more than was expected. This is true of a little boy and girl now at the Children's Hospital. "As the twig's inclined the tree will grow." An infant should be kept lying as long as possible, not allowed to crawl

or walk, and when it does begin, it should have a well fitted celluloid jacket or brace which should be worn almost constantly. Simple exercises may be begun early, including breathings. The apparatus

FIG. 14.—Radiograph of Figs. 12 and 13.

should be modified from time to time or refitted to allow for growth; sometimes a head support is needed, but at all times the apparatus should be arranged to allow free play to respiration.

## THE SHOULDER-GIRDLE.

Total deficiency of the shoulder-girdle has been observed with absence of the arm.

**The Clavicle.**—Defects of the clavicles are rare. They may be absent or partly defective, usually the latter. Unilateral defects may produce lateral curvature. Kappeler saw a double total defect of the clavicles. The patient could walk on her hands although when she sat down her shoulders could be made to touch in front of the sternum. Sherman recently reported two cases, and Marie four. While young, patients have comparatively little disability, but the usefulness of the arms may be considerably restricted in adult life. The deformity is inconspicuous and sometimes has been discovered purely by accident. It may be inherited.

**Treatment.**—Usually nothing is done for it. Sherman advises, if the arm is seriously disabled, that the scapula be attached to a piece split off from the first, second and third ribs, so that the shoulder will remain fixed in a proper position to give a useful arm.

**Congenital Elevation of the Scapula.**—Sprengel's deformity; Hochstand des Schulterblattes; Sprengelsche Deformitate.

This defect is rare; but 100 cases have been reported since Sprengel described it in 1891; about 8 of these were double. The causation is unknown but several theories exist. Rager says that the scapula develops in the neck and fails to move down to its proper place.

The whole scapula is always raised but the degree and the amount of rotation vary considerably in different cases; it is often turned, about the shoulder-joint as an axis, so that the outer border looks downward, and the upper border and the spine of the scapula are crowded into the supraclavicular space, making a great prominence at the root of the neck. It may also turn so that its lower angle lies close to the spines, and the outer border is nearly horizontal; or it may lie so that the entire posterior border is widely separated from the spine, the plane of the shoulder-blade being sagittal instead of frontal and the shoulder well forward; again, the upper angle of the scapula may lie close to the spine and be attached there by an extra bone; this bone sometimes connects the transverse proc-

ess of the seventh cervical vetebra with the base of the spine of the scapula and some have guessed that it might be an extra rib out of place. Lateral curvature of the spine accompanies unilateral cases and some of the bilateral ones.

Eight cases of double deformity have been recorded, all with typical high shoulder-blades, which in one case were considered a family characteristic. Scapulæ may be misshapen, somewhat small, and their position varies in the same way that unilateral deformities do. Owing to the slight range of motion of the shoulder-blade, motions of the shoulder-joint are somewhat restricted. The neck is sometimes very short and thick, so that the occiput comes near the seventh cervical spinous process and the chin to the notch of the sternum. Whether the short neck comes from an increased curvature of the cervical spine, from fused, or absent vertebræ, one cannot tell, for, on account of the short neck, the X-ray picture is obscured by the shadow of the chin. Spina bifida and spina bifida occulta have accompanied it. Bony distortions of the scapula without displacement have occurred in rickets; they have also been attributed to constant pressure from the clothing affecting the growth of a normal young child's bones.

FIG. 15.—Congenital elevation of scapula. (*Children's Hospital.*)

**Treatment.**—There are two forms in vogue, gymnastic and mechanical, and operative, and they may be combined. Gymnastic exercises include very forcible stretchings, and wearing a brace to hold the shoulders back and down; it may accomplish considerable correction if presevered in for over a year. Most cases, however,

require operation, and this mobilizing of the scapula should be preparatory to it.

**Operation.**—Three different conditions may confront the operator: shortened and fibrous muscles, a permanent bending of the upper part of the scapula, and a bony attachment between the scapula and spine. An X-ray is to be studied before operating.

If the elevation be due to short muscles, they are in part fibrous and sometimes fatty, a condition analogous to the sternomastoid in congenital torticollis. The contracted muscles are inserted along the posterior margin of the scapula and the angles at each end of it. The incision, about six inches long, should, therefore, extend over its posterior border, at least, from the top of the scapula to the angle below; the attachment of the trapezius is first exposed and divided, then the two rhomboid muscles and the levator anguli scapulæ; the scapula may then be turned with its posterior border backward and the serratus magnus divided, after which it may be brought down into place unless the distorted anterior surface of the scapula refuses to remain on the comparatively flat surface which the chest wall presents.

A similar but a longer incision is needed in those cases where the upper portion of the scapula above the spine bends forward at right angles with the rest of the bone, or where a large exostosis forms on the upper and inner corner; after exposing the anterior surface of the scapula by dividing the serratus magnus and the other muscles already alluded to, the bent portion—that is the entire upper and inner corner of the scapula and a good part of the bony supraspinous fossa—is cut away with bone cutting forceps.

In the remaining class, where the scapula is attached by an extra bone or cartilage to the spinal column, the whole bony attachment should be excised and all muscles and fasciæ sufficiently divided to replace it in its proper position. The muscles and fasciæ are united by absorbable catgut sutures, layer by layer. and the skin sutured without drainage. After the operation, the shoulder should be put up in a sterile dressing with a plaster-of-Paris shoulder bandage, or this may be incorporated into a plaster jacket with the whole shoulder covered in. By means of a window in the jacket,

the dressings may be changed when necessary, but the new position should be immovably maintained at least three weeks.

The results of operation have not been brilliant; some amelioration of the deformity is usual, and an improvement in the use of the arm, but rarely has a complete and permanent restoration of symmetry resulted. Some advise the operation for children only, but one very successful result has followed operation on an adult patient.

For the scoliosis and the joint stiffness after operation, well-selected gymnastic exercises are indicated, see Chap. VIII, page 114.

# CHAPTER III.

## CONGENITAL LUXATIONS AND SUBLUXATIONS.

### CONGENITAL CLUB-FOOT OR SUBLUXATION OF THE TARSUS.

**Cause of Congenital Club-foot.**—Many different theories have been advanced to explain just how club-foot arises; Bessel-Hagen divided congenital club-foot into two classes, a small class arising from non-development of the bones, and a large class including all others. Other groups might be made, for instance, those due to congenital paraylsis either from spina bifida or cerebral palsy. It is simpler to study club-feet in the old way, to divide them into two groups, the congenital and the acquired, including among the latter deformities paralyses which began before or at birth. It is also simpler to acknowledge that no theory of the etiology has so far remained unchallenged, that the cause is wrapped in obscurity. A history of inherited club-foot is not uncommon.

**Different Sorts of Deformity.**—The abnormal position in which the foot is held varies, hence different terms are used to designate them: equinus, varus, calcaneus, valgus, meaning respectively toe down, toe in, toe up, and toe out; also any combination of these like equino-varus, and calcaneo-valgus, meaning down and in, up and out, etc. Pes cavus, hollow foot, designates a contraction of the plantar fascia and tendons. Pes planus, flat foot, is not often congenital.

**Frequency.**—Talipes equino-varus is the only common form of congenital club-foot, hence unless otherwise specified club-foot means that form. Both acquired and congenital club-foot are common; it has been noted as infrequently as once in 1903, and as often as once in 630 births; the variation may be due to one compiler counting only severe cases of equino-varus. Out of 213 cases of club-foot collected by Roberts, from the records of the New York Orthopedic Hospital and the Orthopedic Dispensary of the University

of Pennsylvania, 5 were equinus, 3 calcaneus, 73 varus, 29 valgus, 95 equino-varus, 3 equino-valgus, and 5 calcaneo-valgus, that is almost four out of five show a well-defined inward rotation and adduction of the fore foot upon the ankle. Simple calcaneus and calcaneo-valgus in infancy are also common in a mild degree and may be disregarded, as they are soon outgrown; only the severer cases persist and require attention. Almost all congenital club-feet are therefore of the varus or equino-varus type.

FIG. 16.—Congenital club foot, talipes equino-varus. (*Children's Hospital.*)

**Diagnosis.**—Diagnosis is often evident at a glance, and the history discriminates between the congenital and the acquired. Differences there are in the degree of deformity and the amount of atrophy. For ease of description the deformity is classed as slight, moderate, and severe; or first, second, and third degree; with reference to treatment the age and difficulty to reduction should also be taken in account: at the Children's Hospital in Boston they are more often spoken of as infantile, walking, resistant, relapsed, and neglected cases.

**Disability.**—The gait in walking and running is peculiar, especially in equino varus feet where the toes point at each other and are lifted over each other in walking, hence the name reel foot. Large callouses form on the weight-bearing surface wherever it may be and still further change the normal outline of the foot. In rare cases walking gives pain; the writer once saw a young woman who had never been out

of the house for that reason; correction of the deformity has enabled her to walk in comfort, so this symptom in no way contraindicates straightening the foot.

**Prognosis.**—The prognosis is excellent if overcorrection be once obtained and if the after-treatment maintains the foot in the over-corrected position until not only the muscles, fasciæ, and ligaments, but the small bones and joints grow into and adapt themselves to the new position. Once this is done there should be no relapses. Unfortunately some relapses still occur, but they are preventable, and remediable. The surgeon should remember that "half cures are no cures," that if the perfect position, or one with a slight calcaneo-valgus be secured and maintained long enough, all will be well; but that relapsed cases are hard to correct. Very rarely has there been a death from club-foot correction. Amputation should only be advised for those whose club-foot is dependent on great bony deficiency in both the leg and foot.

FIG. 17.—Severe grade club feet.

**Treatment** simply aims to overcorrect the distortion and to maintain a straightened position till relapse is impossible. Rectification may be by manipulation, correction in plaster bandage, apparatus, and by the operative methods, tenotomy, division of the ligaments, mechanical forcible correction, open incision, osteotomy and removal of a wedge of bone, astragalectomy. Retention afterward is first by plaster bandage, later by apparatus. Correction, or rather overcorrection, must be complete; with such a choice of methods, if complete overcorrection is not obtained by one method the surgeon should go on and try another and another until it has been accomplished. As a rule infantile club foot in the first three months can be cured by simple straightening applied by the mother's or nurse's hand three times a day, or if more unyielding by plaster-of-Paris bandages. Plaster bandages should include the toes and the knee, semi flexed to prevent the bandage twisting so as to allow a return of the varus

position. The skin beneath the plaster is protected from pressure by thick layers of cotton batting, and in order to protect the bandage from soaking up urine from the diaper shellac or paraffin is painted on from the top half way down the leg. It is best to renew the plaster bandage at rather frequent intervals on account of this. Correction by plaster bandages is, in the writer's opinion, preferable to apparatus for babies who cannot walk; if apparatus is wanted there are special splints for babies which have value; the tin shoe though old fashioned is easy to make and apply. A paper pattern is first cut to cover the sole and rise along the inner border of the foot from the tip of the great toe to a point just below and behind the inner malleolus; from this pattern a tin sole-piece is cut, bent to a right angle where the inner border and sole join; a wire upright is soldered on rising to a point half way between the ankle and knee, crossing to the outer side and ending at the trochanter in a pad; the sharp edges of the tin are covered with adhesive plaster, the upright is thickly wound with cotton flannel, the sole plate padded with felt; the splint is applied by first bandaging the foot to the sole plate without regard to the position of the upright, then bringing the upright into place and holding it there with another bandage. For older babies the Taylor club-foot shoe may be similarly used in a simplified form, substituting a stiff bandage for straps and buckles and making the upright without a joint at the ankle, and in order to evert the foot extending the upright to the waist, where it ends in a T-shaped plate jointed to the upright over the trochanter with the horizontal arms ending in a strap and buckle at the anterior and the posterior spines of the ilium respec-

FIG. 18.—Relapsed club foot.

tively. Babies' feet are too small to be held by straps to a sole plate. When correction of deformity is the object the tin split, or Taylor shoe, should be reapplied at short intervals by the surgeon, who from time to time bends the upright to obtain better position as the deformity slowly yields; used for retention only it may be seen less frequently by the surgeon.

**Operative Treatment.** –An infant is never too young to begin corrective treatment; as a rule the earlier the easier, yet there are some feet which refuse to yield to manual correction or simple corrective apparatus. Under anesthesia these may be overcorrected by using stretching force, applied either with the hand or wrench, or by tenotomy, subcutaneous division of ligaments, open division of all resisting parts. Bone operations are unnecessary before the age of walking.

**Tenotomy and Fasciotomy.**—Tenotomy, or subcutaneous division of tendon, requires a special little knife called a tenotome; those on the market are too large as a rule, both the sharp and blunt pointed; a single sharp pointed tenotome is enough for all tenotomies; the cutting edge should be one-quarter inch long and the extreme width at the base one-eighth of an inch, no more. A stout round shank one inch long and an eighth of an inch in diameter joins it to the handle. Fascia and ligaments are divided in the same way as tendons.

The tendons most commonly divided for equino-varus are the tibialis anticus, tibialis posticus, and the tendo Achillis, but every tendon is within easy reach in the foot, and may require division. Anæsthesia is not always employed for tenotomy in England, here it is the rule.

Tenotomy of the tendo Achillis is done with the patient lying on the side; an assitant grasps the fore foot so as to make the tendon tense, the operator enters the tenotome through the skin to the side of the tendon, about half way between the heel and the muscular belly of the gastrocnemius, passes the point to the remote side flat on the tendon, then turns the cutting edge towards it and with slight to-and-fro movements divides the tendon across. The forefinger of the operator's other hand pressing over the back of the knife

assures him of its whereabouts. Division must be complete, the gap between the severed ends at least a finger's breadth wide; one judges of this by pressing the finger into the gap where any small undivided tendinous bands may be felt and tenotomied. Immediate fixation in a plaster bandage should follow, with a small pad of sterile gauze or cotton over the puncture. Bleeding is disregarded, unless sufficient to imply puncture of a large artery like the posterior tibial. Elevation of the limb or pressure often stops the bleeding, or in cases of doubt immediate operation for ligature may be done. With the knowledge obtained from his forefinger of the position of the knife's point, the surgeon runs almost no risk of wounding anything unintentionally.

The tibialis anticus tendon is felt so plainly when on the stretch that it is only necessary to make it tense, enter the knife and cut nothing but tendon; tenotomy is much safer below the annular ligament, where the position of the dorsalis pedis may be verified by palpation.

The tibialis posticus tendon is less easy to reach. The point often selected is on a line half way between the posterior border of tibia and the inner side of tendo Achillis the width of the thumb above the maleolus' tip; the tenotome is directed straight in for half an inch, then the point is swept in toward the tibia while the foot is forcibly abducted to put the tendon on the stretch. The danger is lest one cut the posterior tibial artery. Puncture of this artery has produced a small aneurism which later needed ligation; hence some surgeons prefer an open incision.

The tibialis posticus tendon is more safely reached from a point immediately in front of the inner malleolus in the baby's foot, and in the adult, a finger's breadth in front of it. By directing the tenotome inward and downward the surgeon reaches the inferior astragalo-scaphoid ligament and opens the astragalo-scaphoid joint, dividing, at the same time, the posterior tibial tendon as it passes beneath the bones. From the same incision the insertion of the tibialis anticus muscle to the tubercle of the scaphoid is easily reached and the astragalo-scaphoid joint is freely opened laterally. In correcting club-foot by tenotomies the tendo Achillis is preserved

till the varus position has been overcorrected, for it gives a solid ankle on which the fore foot can be manipulated, as all firmness is lost when it is cut. After tenotomy forcible stretching to gain better position is used with the hand or Thomas wrench.

Fasciotomy of the plantar fascia is needed in more than half of the operable feet. A complete division may be made by entering the tenotome on the inner side of the sole one-third of the distance from the heel to the ball of the foot, pushing the point just under the skin as far as the outer border of the foot and cutting upwards freely while the assistant pressing on the ball of the foot and toes makes it tense; as band after band gives way the fore foot yields with a slight noise. After dividing deeply all the way across the foot the surgeon feels with his finger for more bands of fascia to tenotomise giving to the foot as much dorsi-flexion as he can. Another method is to stretch and cut all tight bands in the sole wherever they are felt, instead of dividing the whole width of the fascia. Relapsed cases may require a second or third fasciotomy; repeating the operation is without ill effect. All tenotomies, fasciotomies, and subcutaneous cutting should be performed with strict asepsis and protected from infection for a fortnight.

Division of ligaments is at times necessary in infants and is frequently to be performed on comparatively mild looking club feet in walking children. The astragalo-scaphoid ligament is reached from a point between the tubercle of the scaphoid and the anterior corner of the maleolus; the joint can be first made out by palpation and the knife cutting towards the joint divides the upper and inner fibres, then the lower and inner ones. It sometimes happens that free cutting away of this ligament will release the deformity so much that section of the tibial tendons becomes needless. The operation is done subcutaneously with the tenotome.

The calcaneo-cuboid ligament should also be divided in cases with much deformity. The joint can be felt in a thin patient a short ways back of the prominence of the proximal end of the fifth metatarsal bone. A sharp-pointed tenotome is used, dividing everything to the bone and striving to cut into the joint and to divide the whole ligament.

The after-treatment is overcorrection in plaster bandage for two or three months; then a club-foot brace and plenty of walking on it for eight months or two years or long enough to grow straight joints and a muscular development which will maintain the new rather than the old position. This takes years, and it is hard to tell when this has been attained; apparatus should therefore be continued too long rather than too short a time and be left off gradually. Daily manipulation by the parents and rubbing are of the greatest value while apparatus is in use and are the best safeguards against atrophy and stiffness.

**Mechanical Appliances.**—Retention apparatus for walking children should allow the greatest amount of freedom consistent with the prevention of a return to the deformed position. There are many splints and devices to correct club-foot. At the end of the book (Chap. XXI), will be found the description of one which has been used for some time in the Children's Hospital. Great care must be used by the parents in applying apparatus properly as it too often happens that relapse may be traced to such neglect. Careful oversight must be maintained during the first months of treatment so as to instruct and to watch the efficiency of the apparatus. Except for the very mildest club-feet, *in walking children* corrective apparatus has been discarded in favor of operations because the length of treatment is much greater when apparatus alone is relied on.

FIG. 19.—Manual correction of varus, club-foot.

**Forcible Correction Under Anæsthesia.**—Forcible manual correction has been strongly advocated by Lorenz, of Vienna, for both walking children and for neglected cases; the chief advantage over other operations lies in the fact that all parts of the foot participate in the correction instead of a limited portion, as in osteotomy, or removal of a wedge-shaped piece of tarsus.

This method, rapid manual correction, is no more curative than any other and requires precisely the same prolonged after-care until all danger of relapse is passed. Under ether the inward position of the fore foot is first overcome by grasping the heel in one hand so that the thenar eminence is on the cuboid and affords a fulcrum on which the other hand may bend the fore foot outward by a series of increasing pressures and relaxations, until it is completely stretched and motion in that direction is a little more free than in a normal foot; if greater force is needed than the hands alone can give, the triangular block of wood is used as a fulcrum, the heel and inner border of the fore foot are pressed on with the hands. After all resistance is overcome in this direction the ankle is grasped and the foot twisted to bring the outer border higher than the inner, the direction of the twist being outward-and-upward and the force is applied on the sole beneath the cuboid to prevent its dropping down in the sole. No rigidity or elastic recoil to the deformity should remain now except that from the short tendo Achillis and the plantar fascia. To stretch it, simple dorsi-flexion is employed, with the child lying face down, the knee flexed at a right angle; the operator hooks two fingers about the tips of the heel, pressing down with the ball of the hand on the ball of the foot and toes, while the ankle is steadied with the other hand; it is essential that the tendo Achillis be intact to offer resistance. Finally if it refuses to stretch, as it may do, the tendo Achillis is tenotomized, and sometimes the posterior fibres of the ankle-joint too; the foot should hang perfectly limp and the toes almost touch the front of the shin when the stretching is finished. The first plasters extend from beyond the tips of the toes to the upper third of the thigh with the knee flexed and with a very heavy sole of plaster re-enforced with wood to walk on. Great care is used in holding the foot overcorrected during the setting of the plaster. On the next day but one they, Lorenz's patients, begin to stand and walk, in order that the weight of the body may still further stretch and correct the deformity. Whitman changes the plaster bandage in a month and allows the free use of the knee from then on. At three months he substitutes a light brace worn inside the shoe. With this is added massage of the

whole leg and foot and passive movements twice a day to carry the foot as far in all directions as it went at the end of the operation.

**Wolff's Method.**—Rapid manual correction with less force and with an imperfect immediate rectification has been advocated by Wolff, of Berlin; after an incomplete correction of deformity he applies a plaster-of-Paris bandage, and three or four days later cuts it around the ankle, removes a wedge like piece from the outer side of his cut, crowds the edges together, and holds what he gains with a few turns of fresh plaster bandage. Larger and larger sections are removed every few days until complete overcorrection is reached. Then by covering the bandage with shavings, cloth, and glue it may so strengthen that it may be worn six months or a year without change.

FIG. 20.—Corrected club foot held in overcorrected position at end of operation, ready for plaster bandage.

**Club-Foot Wrenches.**—Several different forms of wrench have been used to correct the deformity of club-foot. The Thomas wrench is in general favor and has stood the test of time. Its use is readily understood from the illustration (Fig. 21). A more scientific instrument has been devised by Bradford; McKenzie, of Toronto has more recently described his wrench, and there are many others. Personal experience has led the writer to return to the use of a wrench after abandoning it for several years.

**Phelps' Method.**—The method of correction by free open incision was advanced by Phelps. It has the advantage of facility and allows the inspection of every step taken. The incision is made from the tip of the inner malleolus to the middle of the sole, or it may be made along the line of the first metatarsal; all contracted tissues are divided in plain sight including ligaments; the artery and nerve are isolated and preserved; after completing the operation the foot should hang limp without returning to the deformed position. Partial sut-

ure of the skin is desirable for there is some danger of relapse from the slow contraction of this large mass of scar tissue.

**Operations on the Bones.**—Osteotomies and resection of bones are of use principally for the neglected and the relapsed cases; the surgeon prefers milder methods because he avoids correcting one deformity by producing another, which is what all bone operations on the foot do; nevertheless the principle should be adhered to of doing everything necessary to secure a straight foot. The altered plane of the astragalo-scaphoid joint and that of the cuboid and calcis offer at times an insuperable obstacle to any other method of treatment.

FIG. 21. Thomas' wrench.

Since there is great change in many club-feet in the obliquity of the neck of the astragalus and in the direction of its articular facet, it must often be osteotomied to rectify the deformity. In the baby or young child whose astragalus is cartilaginous, one may pull the scaphoid into place and hold it there long enough for slow adaptation to take place by growth, but it is hard to see how perfect adaptation can come later in life if there be great change of the direction of the astragalus' neck. Osteotomy of the neck is only done after a thorough stretching and dividing of all short tissues; the incision is from the tip of the malleolus to the inner side of the proximal end of the first metatarsal; it is a short incision and reveals the tibialis anticus tendon close to its insertion; using it is a guide, the astragalo-scaphoid ligament is divided, which allows the scaphoid to slip forward and expose the neck of the astragalus for chiseling; sometimes it is better to remove a bit of the neck or even the entire head of the astragalus, in which case the plane of the cut makes a great difference; it should be at right angles to the axis of the foot and must look upwards as well as forwards so as not to impede dorsal flexion. The subsequent treatment does not differ from that for a tenotomized club-foot, only the skin is sutured and the first plaster is worn six weeks undisturbed if a catgut suture is used.

*Osteotomy* of the anterior portion of the os calcis is indicated where there is great prominence of the foot's outer border which fails to

reduce under all other means; like the distorted astragalus neck it may straighten by growing in a young child whose bones are still soft and cartilaginous, but if ossification be complete it is more apt to force the cuboid down into the sole of the foot so as to gain room for itself. This dropped cuboid is a very painful thing to walk upon. To prevent it the removal of a large wedge of bone just behind the anterior articular surface of the calcis has been satisfactory. If, after tenotomies, division of ligaments, and forcible correction under ether with wrenches, this part of the deformity be still unyielding, a curved incision is made on the outer border of

FIG. 22.—Result of astragal ectomy. (X-ray from *Children's Hospital.*)

the foot from the tip of the malleolus to the point of greatest outward prominence, exposing the peronei tendons and the periosteum; they may be retracted or divided and the osteotome is entered into the outer side of the os calcis a quarter of an inch back of the cubo-calcaneal joint and parallel to it; after severing this end of the bone the osteotome again divides it at least a finger's breadth further back in a plane looking forward and outward, and the intervening wedge of bone is removed; the shelf-like sustentaculum tali offers considerable resistance to complete division and has to be fractured after partly dividing it. When the fore foot swings and the cut surfaces of cal-

cis are brought together one must see whether overcorrection has been really achieved; if not the removal of another slice will often suffice. If the perineì tendons were cut they should be sutured again and shortened. The skin may be redundant and it is a good plan to cut off some of the excess; a small drain may be left to allow for oozing from the bone and to be removed in a few days; dressings are done through a window in the plaster bandage without disturbing the position of the foot.

**Combined Operations.**—These operations are at times combined with good effect. Sometimes the malleoli give insufficient room for the anterior part of the body of astragalus which is always wider; this prevents dorsi-flexion or else the external lateral ligaments of the ankle tear and stretch and the fibula stays too far back, in other words there is a partial dislocation of the foot forward on the leg at the ankle. Whitman describes an operation he calls malleotomy for the correction of this condition. After dividing the contracted tissues at the back of the ankle, he cuts the ligaments through an anterior vertical incision and pries the malleolus out with a thin chisel inserted between it and the astragalus, suturing the ligaments after replacing the astragalus.

Many different sorts of resections and enucleations of bones have been tried and abandoned; cuneiform resection of the tarsus is done less and less on account of resulting shortening and stiffness, although the end results have generally afforded serviceable feet for walking. With so many resources at the surgeon's command it should never be said that a congenital club-foot is incurable.

## CHAPTER IV.

## CONGENITAL DISLOCATIONS: HIP, KNEE, PATELLA, ANKLE, SHOULDER, ELBOW, WRIST.

### CONGENITAL DISLOCATION OF THE HIP.

Congenital dislocation of the hip is not very rare. Out of 332 dissections of the hip-joint at the Hospital des Enfants Trouves, Parise found it three times. In this country it exists more often than once in two thousand births. About eighty-five percent are girls and fifteen boys; no reason is known for it. It is also a little more frequent on the left side, but the double cases may be almost as common.

Sometimes it is found luxated in the fetus, and again it is only dislocated when the child begins to walk, or later on by a fall or slight violence. It is supposedly due to a perverted growth of the bones. Some attribute it to a spontaneous dislocation from paralysis or bone disease in the fetus, but the evidence of these conditions is entirely wanting; violence at birth is not a direct cause, but may act to dislodge an already insecure joint. Jackson Clark considers that continued flexion of the hip produces it; a firm contraction of the anterior portion of the capsule has been demonstrated by him in an eighth month fetus. The undeveloped state of the acetabulum may be due to displacement of the head early in fetal life; if the head of the femur does not lie in its socket, the socket does not grow properly. But after all one only knows that the cause is congenital.

**Disability.**—In little children the disability is slight, the limp becomes gradually noticeable and sometimes, in double congenital dislocation, it is distressing by the time three years is reached; double dislocations do not limp, they waddle. The older and heavier one is the more annoying the lameness, but except in a few instances disability

from double dislocation does not prevent walking till middle life or old age. Adults with a single dislocation may be unable to undertake steady active work, and may suffer from attacks of pain or from muscular cramps which subside under rest. Obesity and feebleness are the things to dread, although crutches prolong the activities of life. Muscular patients suffer less than weaklings; double dislocations are more disabling than single; those whose

FIG. 23.—Single dislocation.

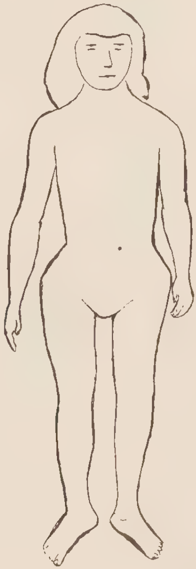

FIG. 24.—Double congenital dislocation, broad perineum and prominent trochanters.

dislocated head rests above or in front of the socket have less disability; the general trend is to remain stationary or to grow worse slowly. Such is the life history of the untreated and of the failures. Little by little surgical skill has found ways of bringing about permanent reduction and cure, and although the proportion of failures is considerable it grows steadily less.

Froelich, of Nancy, however, reports two exceptional cases of

spontaneous cure of congenital dislocation of the hip. They were double dislocations and X-rays were taken before and after the cure.

**Pathological Anatomy.**—Much attention has been given to the study of pathological specimens and considerable variation exists. In the fetus or the infant who has not crept, the displacement is naturally less than in those who have walked. The capsule becomes lengthened by stretching from carrying the body-weight as if it were the strap of the old fashioned C spring on a carriage, the fixed point being the upper part of the femoral insertion near the trochanter, and the movable end the pelvic attachment. Part of the capsule rising from the lower

FIG. 25.—On the right the capsule is stretched as in a dislocation on the dorsum ilii, on the left one sees how drawing down the hip may fold the capsule in front of the head.

part of acetabulum forms a covering of dense tissue right across it, shutting it off from the rest of the joint cavity except for a small opening at the side or rear; this opening between the acetabulum and the cavity around the end of the femur is often too small to let the head pass through, and too unyielding to be stretched by it post-mortem, and has been called the "hour-glass constriction of the capsule." Lorenz found a way by which he can often pass the femoral head through it. When the constriction obstructs the passage of the head, the portion between it and the pelvis may be folded into the acetabulum in front of the head, and an

insecure reposition be made in this way. This happens in life and has been verified by operations and by dissections, after apparent reductions.

The displacement of the head of the femur may be backward. upward, or forward; the backward or dorsal luxation is the most common. The inclination of the pelvis varies accordingly, for the

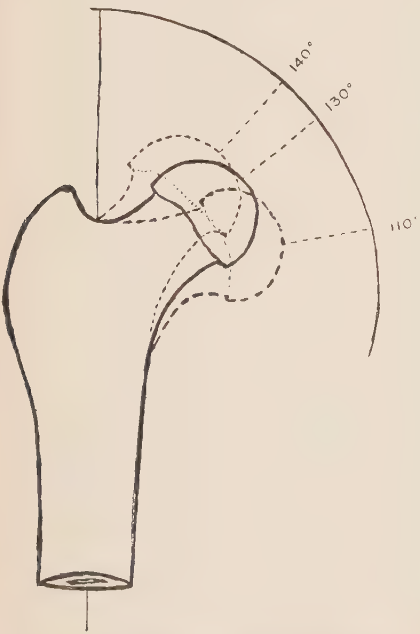


FIG. 26.—Diagram of different angles of elevation of the femoral neck.


FIG. 27.—Femur from congenital dislocation of the hip showing small and deformed head and coxa vara.

point of support is either above or behind the acetabulum, and the further back the more the pelvis tips and the more lordosis there is in the spine.

Muscles alter in consequence of the changed relations, some shorten some lengthen; the gemelli, obturators and pyrimiformis are long, the adductors, hamstrings, and ilio psoas are short, the

glutei and quadriceps of nearly normal length but are often slightly atrophied.

**Changes in the Bones.**—Changes are seen in the femoral head, and neck, the acetabulum and the surface of the ilium opposed to the dislocated head.

The head of the femur is small and not globular; it is flattened, and at times conical. The angle made by the neck of the femur with the shaft is subject to considerable variation in normal individuals; it varies both in the obliquity with which it sets upon the shaft, and in the amount it twists from the frontal plane. The normal angle of elevation is in children 135°, in adults 125° or less, the normal torsion is from 12°–25° forward, but normal bones may vary from 6° behind the frontal plane to 40° in front. These figures are greatly exceeded in congenital dislocation of the hip. When the elevation approaches a right angle, coxa vara is present, when approaching the axis of the shaft, coxa valga. Either may occur, but in those who walk the body-weight slowly bends the neck down towards the right-angled position, or coxa vara, and this deformity is common. The amount of torsion of the neck is often abnormal and may be misleading in attempting a reduction.

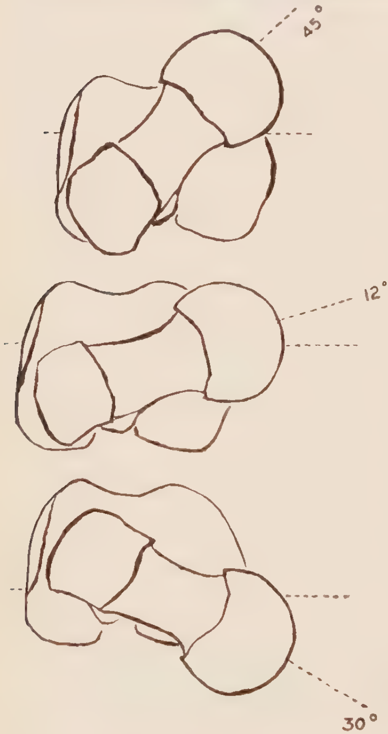


Fig. 28.—Diagram of different torsions of the femoral neck.

Abnormal torsions are seen from 45° behind the frontal plane to 90° in front. The unused acetabulum is lined with cartilage

and with synovial membrane over the cotyloid ligament; it is partially filled with a fibrous and fatty tissue and it is shallow. In infancy it is very little changed in form or structure, but in adolescents it becomes small and triangular. One is surprised usually at the apparent depth of the sockets seen at operation; one must remember that this depth is greatly due to that cartilaginous and ligamentous ring, the cotyloid ligament, and that the alterations in form affect this easily; it seems as if the strong pull of the suspended body-weight through the capsule thickens the cotyloid ring and so deepens the acetabulum when really there is a small, shallow bony socket.

FIG. 29.—Congenital dislocation of both hips. (*Children's Hospital.*)

The surface of the ilium against which the capsule covered femoral head presses becomes hollowed out into a secondary socket. This is a superficial depression and quite insecure, with a thickening of the bone at the periphery produced by the irritation of the periosteum. After remaining for some years in one spot the position of the dislocated head may change, hence several secondary sockets may form. No surgical importance has been given to them.

**Symptoms.**—Symptoms of congenital dislocation vary with the kind and amount of displacement, and with the age and activity of the patient. Infantile dislocations pass unnoticed, first, because not walking they do not limp, second, because the head often stays in the socket until the child begins to walk, third, because shortening and moderate flexion of the hip in a baby may escape notice. At times a peculiar breadth of the pelvis, a lump on the buttock, a snapping about the hip-joint or a peculiar way of holding the limb leads

the parents to seek advice early. Usually when walking is well established at two, three, or even four years of age it is noted that the child's back is hollow, the buttock unduly prominent, that it waddles, or limps. Waddling is quite typical and the deep sudden dip as the weight falls on dislocated hip has been likened to "taking a step down stairs," only there is a sudden lunge or roll to the affected side as well as the quick dip downwards. There is no pain, or muscle-spasm. In older children and in most adults the prominence of the buttocks and trochanters with well-marked lordosis cause an attitude strongly characteristic of the affection.

**Physical Signs of Congenital Dislocation.**—The chief sign of congenital dislocation is abnormal mobility of the hip and shortening. Shortening is measured in two ways; by a comparison of the distance between the anterior superior spines of the ilium and the internal malleolus of each limb, and by noting the relation of the trochanter major to Nélaton's line. The former gives reliable data only in unilateral dislocations. Nélaton's line is drawn from the anterior superior spine of the ilium to the tuberosity of the ischium of same side; it should pass a trifle above the top of the trochanter in a normal hip, in congenital dislocation the trochanter is from a half inch to two inches above the line.

Abnormal mobility of the hip is tested with the child lying flat on his back, by making tractions in the line of the leg with one hand, while the other resting on both the anterior part of the iliac crest and the trochanter feels the trochanter moving under the skin as it is drawn down; on letting up the pull it glides up again; on manipulating young children's hips are found unusually movable especially in rotation, and the thigh can often be twisted and the toes made to point more or less backward.

In a double dislocation the perineum is broadened, generally the heads of the thigh bones are far back, the pelvis tipped well forward, the hollow of the back is much exaggerated, the abdomen protrudes, the whole pelvis appears widened, and the buttocks project far behind the shoulders and but little behind the line of the posterior surface of the thighs.

**Trendelenberg's Test.**—A valuable physical sign of congenital

dislocations is obtained by having the patient stand on one leg. The normal individual fixes his pelvis in balancing so that the buttocks are level with each other; standing on a dislocated hip the side of the raised foot falls, while in coxa vara the reverse takes place, it rises. It is of equal value in unilateral and bilateral luxations; both legs should be tried alternately. This is known as Trendelenberg's test.

FIG. 30.

FIG. 31.

FIG. 32.

FIG. 30.—Lordosis in double dislocation.
FIG. 31.—Trendelenberg's test, standing on luxated hip.
FIG. 32.—A normal child standing on one leg, the buttocks are horizontal.

**Diagnosis.**—The symptoms and signs are generally plain, the diagnosis offers usually no difficulty. There are many cases, however, where it is impossible to make it at a glance; but the whole picture, the attitude, gait, measurements (especially from Nélaton's line), abnormal hip mobility, drawing down and sliding up of the trochanter, the lordosis, and in double cases the broad perineum, and

finally Trendelenberg's test of the line of the pelvis when the patient stands on one leg—all these carefully observed should leave no room for doubt. Other affections may be mistaken for it, however; among these are coxa vara, paralytic distortion from anterior poliomyelitis, separation of the upper epiphysis of the femur, pathological or traumatic, traumatic dislocation of the hip, even hip disease and spinal caries; the latter on account of the lordosis only.

FIG. 33.—Congenital dislocation of the left hip in a child of two with spina bifida occulta. Note the great width of the two last lumbar vertebræ and the smallness of the pelvis on the side of the dislocation. (*Children's Hospital, Dr. A. W. George's X-ray.*)

Absence of pain and tenderness, and absolute freedom of motion, even an excess over the normal motion, rule out all but coxa vara and paralysis; in these the head should be in its socket, if it can be felt outside they are excluded. The head can be felt as a round resisting mass under the femoral artery where it begins at Poupart's ligament if it is in the socket, otherwise it is not there. Diagnosis

is confirmed by taking radiograph'c plates. Radiography should, however, also be used to furnish more precise knowledge of the femoral deformity than one can acquire by palpation. It is sometimes easy to feel that the head is out of place but it is impossible to feel exactly where it has gone, and unless this be known the amount of torsion of the neck upon the shaft of the femur remains unknown, and this ignorance cause failure to reduce or may even leave the trochanter instead of the head against the acetabulum. To ascertain by radiography the torsion of the neck one may take a series of plates, each with the patella pointing a different way, which is noted at the time of exposure; in one the toes should point inward and upward forty-five degrees with the horizon, in another straight up, another upwards and outward forty-five degrees, in another in extreme outward rotation; the patient remains lying on his back and the X-ray tube vertically above the hip. Whichever one of the skiagraphs shows the longest neck shows it in the horizontal plane; and knowing the position of the foot recorded at the time of exposure, one can readily, by rotating the thigh, place the limb in a position with the neck in a frontal plane and then bringing the axis of the condyles horizontal, one can follow the direction of the neck and know whether torsion be forward or backward and estimate it approximately in degrees of a circle.

## TREATMENT.

**Palliative treatment** aims at the palliation of an irreducible condition not at reduction. Unfortunately but little has been done for the palliation of the irreducible luxations. By gymnastic exercises the muscles may be strengthened and the attitude and gait greatly improved; they must be persevered in for years or for life, and really they do the most good. Mechanical appliances like the stiffened leather jacket and the corset may improve and correct lordosis and in that way improve the walking. They must fit tightly about the pelvis. Kirmisson uses the stiff leather jacket with prolongations around the thighs and a turn buckle between the thigh pieces to spread the legs. A steel back brace with a well-

fitted low metal band around the trochanters has been used by Young. Various plaster-of-Paris jackets and pelvic supports have been tried, and tight belts. Tenotomy or open division of the adductors has improved the cross-legged gait and Kirmisson used subtrochanteric osteotomy with advantage in adults. All the various splints which are used for hip disease and infantile paralysis have been tried. In adults stiffness replaces the previous laxity and temporary benefit may come from forcible manipulating and stretching under ether to restore hip motion; this gain should be maintained by exercises. For the attacks of pain and cramps in the muscles rest in bed and massage are usually all that is required.

Adults and adolescents with congenital dislocation of the hip have been considered doomed to lifelong deformity, but Baer, of Baltimore, has reduced a double one twenty-five years old by incision and excavating the acetabulum; he failed on the second hip two years later. A small number of individuals over the age of puberty have been successfully reduced by various methods, although the proportion of failures at that age has been very great. May one not expect in the future to see them classed with adult club-foot, as reducible?

**Reduction of the Dislocation.**—Reduction of congenital dislocation of the hip has been done by stretching the contracted muscles and tissues and replacing the head of the femur in the acetabulum without the use of the knife; and it is also done by incision and dissection; so there are the bloody and the bloodless methods of reducing the dislocation.

Prior to 1887, with one exception, the deformity was reduced but seldom and then only after many months of traction by weights in bed. Provaz, of Lyons, in 1847 had reduced fifteen cases—the preliminary extension lasted six months, the whole treatment two years.

**Simple Manual Reduction.**—The first bloodless reduction under ether was performed by one of the surgeons at the City Hospital in Boston, Abner Post, in 1885. The case relapsed later. An Italian surgeon, Paci, showed at the International Medical Congress in Rome, in 1887, several patients successfully reduced by his manipulations.

Lorenz, of Vienna, studied Paci's method and worked out a scheme for bloodless reduction which has been used extensively by many with varying success.

Schede divised another method. He used traction and abduction in a machine every other day and after several tractions reduced the hip and held it straight in plaster. Bradford and R. W. Bartlett devised a machine for stretching the shortened muscles, reducing the dislocation by the Lorenz method. Recently Mueller, of Chicago, devised a better position in which to hold reduced hips in plaster.

To Hoffa, of Berlin, is due the credit for a cutting operation of real value; also a method of bloodless reduction. It was modified and used extensively by Lorenz, who later discarded it almost entirely in favor of his bloodless reduction. Hoffa had previously been resecting the femoral head with poor result. A combination method, bloodless and bloody at one sitting has been used; and several different routes are employed to gain access to the joint.

Experience with all methods has shown that unless the reductions are performed on children the proportion of failures is very great. Double congenital dislocations should be reduced before five, single before seven, by the purely manual method. The mechanical method and operation by incision offer a fair chance to children two years older.

**Lorenz Method.**—The bloodless method of Lorenz requires full anæsthesia; the patient lies with the legs over the end of the table. The surgeon stretches by pulling and twisting the leg, the assistant holds the pelvis firm and fixes it in one position; at first by strong downward tractions the trochanter is brought down to Nélaton's line, this is followed by forced rotations inward and outward; it then is forcibly abducted to a position at right angles to the body and a little beyond both with a straight and a flexed knee, the surgeon's hand kneading and striking on the belly of the adductor longus aids materially in the stretching; when the adductors are stretched, that is when abduction can be carried twenty degrees beyond a right angle with the body, the limb is brought again into a straight position. The next step is to stretch the hamstrings so the foot is

raised, without bending the knee, until the front of the thigh meets the abdomen and the toes the face. Next the head is made to dilate the capsule; the thigh is flexed beyond a right angle and the surgeon presses down and forward on the knee, twisting and trying to stretch the anterior part of the capsule and to free it from adhesions, and striving to get it below and a trifle in front of the socket. Then, to stretch the anterior muscles, with the patient on

FIG. 34.—Double congenital dislocation of hips. (*Children's Hospital, Dr. A. W. George, Radiographer.*)

his side or face, the hip is hyperextended both in the straight and in extremely abducted position, taking care that the assistant really holds the pelvis and does not allow lordosis to simulate stretching the ilio-psoas. The hip should now be ready for an attempt at reduction. The surgeon grasps the knee with the hand (right hand for right leg), flexes the thigh to a right angle, rotates inward, flexes and abducts slowly, keeping his other hand with the palm pressing on the crest of the ilium the thumb pushing from behind

upon the trochanter, trying to guide and lift it over the rim as the hip reaches the overabducted position, using also a little twisting of the knee as the thumb lifts and presses the trochanter. A wedge of wood about three inches high padded on top with leather may be used to rest the trochanter on and do the lifting. Failure means insufficient stretching and so one tries again after manipulating-some more.

When it reduces there is generally a sound and a sudden jump as in reducing a traumatic luxation; absence or marked lessening of this phenomenon may mean a fold of interposed capsule or a misfit joint. It is well in this case to dislocate and to reduce several times. Often a little straightening of the leg will redislocate; the amount of motion permitted without slipping out is a sign of security and of ultimate success. Insufficient stretching may cause it; this is to be remedied by more stretching. It is not possible to retain the head in place when the axis of the limb parallels the body, but this may be done if the trochanter is held in with the hand. How is one to know if the head is really in place? If in the acetabulum, it lies beneath the intersection of Poupart's ligament and the femoral artery; when present it can be made to roll under the finger by rotating, when absent one misses the fullness there.

**Application of Plaster Bandage.**—The application of the plaster bandage is fraught with danger of relapse. A piece of stockinette, sewed up like drawers, is put on with a piece of bandage inside for a scratcher, the ends emerging at the top and bottom, that is at the ankle and axilla; over this a few layers of sheet cotton wadding with felt over the bony prominences of the pelvis to diffuse pressure; then a firm cotton bandage about the pelvis and upper thigh; then a solid plaster bandage tightly applied with the hip held in "hyperabduction, hyperextension, and outward rotation." If the dislocation be double, the position is the so-called "frog position." The top of the plaster is cut low in front to allow sitting up; it extends high above the iliac crests on the sides and back; at the knee it is cut away in the popliteal space to allow flexion and extension, but covers the front and sides of that joint to prevent rotation. The writer has had radiographic negatives made through these plasters to show that the reduction has been maintained within the plaster. (Fig. 35.)

The first plaster is worn two months or more, and replaced by another with a slight straightening but maintaining still the outward rotation for two or three months more, then another, a total of five or ten months in plaster. The first few days are spent abed on account of the painful swellings from ecchymoses and torn muscles and nerves. Then the child gets up, is provided with a boot and high sole and soon learns to get about on his feet, if unilateral;

FIG. 35.—Congenital dislocation of hip reduced and in plaster bandage. (*Children's Hospital, Dr. A. W. George, Radiographer.*)

double reductions learn to straddle a low bench and use their feet in hitching it along; later they learn to walk sideways like a crab, supporting themselves with a stick. Unilateral cases need a very high sole at first, often six inches; crutches are not used by Lorenz, as he wishes the weight-bearing to cause absorption of the fibrous fat in the joint and the slow adaptation of a head and socket often quite dissimilar in shape.

Mueller, of Chicago, calls attention to the extreme forward torsion of the neck on the shaft of the femur described by Schede and Lange and thinks that this factor is responsible for many relapses after reduction. His new position for the plaster bandage he calls a neutral position of right-angled abduction to the trunk, one where the patella is approximately in the frontal plane and the leg and foot as the patient lies in bed hang down over the side. This method has been tried at the Children's Hospital on all the reductions during the last nine months, and although it is too soon to speak of the results they promise well so far.

**Reduction by Machine.**—Manipulative reduction by manual force

FIG. 36.—Plaster bandage after reduction applied in Mueller's position.

is tiresome and difficult, especially in older children, and more or less inaccurate; it produces more laceration of the tissues than is necessary and swelling and bruises give much pain during the first few days. A machine for stretching the contracted tissues in congenital dislocation was devised by Mr. R. W. Bartlett, of Boston, and described by him in 1903. The one here described is in use at the Children's Hospital; it was devised by Bradford who had previously used Bartlett's machine on some forty reductions.

Two steel plates, one-eighth of an inch thick, measuring ten by twelve inches, are fixed over each other with a half-inch space between

and so arranged that one of the ten inch sides can be attached to the edge of a table by a vertical front plate which is bent so as to grasp the under side of the table top. This rests flat on the table; it is perforated with half-inch holes every two inches to hold cylindrical steel rods or pegs about nine inches long. The vertical front plate is also perforated. A long steel traction arm with windlass or screw-and-spreader, five pegs, two metal sleeves, a short straight lever, and two collars bearing each a flat arm to hold the pelvis, complete the apparatus.

The child lies on its back with a soft pad under the sacrum and the perineum against two sleeve-covered pegs placed in the centre holes of the horizontal plate. Traction is usually applied with a long thong of raw-hide wound about the ankle previously protected with felt and leather padding. One end of the traction arm rests in a hollow or vertical plate beneath the hip, the assistant secures the thong to the windlass and winds it to make powerful traction, the pelvis having been secured against slipping by a peg on each side of the ilium bearing the collars and short arms which rest upon the anterior spines and symphysis pubis. During traction the limb is rotated alternately inward and outward with force, and the traction rod and limb are slowly forcibly abducted. After reaching a position a few degrees beyond a right angle to the body axis with the limb horizontal the leg is straightened and the abduction repeated with the foot on a plane considerably lower than the hip. By placing the end of the short lever in the hole next to the perineal peg, and lifting, pressure is directed on the trochanter, the head is forced well forward to stretch the capsule, and at times reduction may take place. Nevertheless the hamstrings are to be stretched as in the Lorenz method, unshipping the traction arm. The reduction is then possible if there has been enough stretching and it may be done with the hand, or the short lever may be used to pry the trochanter up over the rim. Insecurity is again either a sign of incomplete stretching, of infolded capsule, or of an acetabulum unsuited to hold the femoral head. More manipulating will remedy the first condition, not the others; if, therefore, it fails to give a more stable hip, the surgeon may either

apply a plaster bandage in the position of greatest security and wait, or he may at once proceed to the bloody method of reduction by incision, and in some cases this combined method is rational.

That position of the hip which resists most strongly all attempts at dislocation appears to be the rational one to use for the first retention bandage. It is frequently one of marked abduction and inward rotation; it is here that a knowledge of the way in which the neck of the femur sets on the shaft should aid the surgeon, a knowledge gained by previous radiographs as described on page 47.

**Tenotomies.**—Where failure to obtain a stable reduction arises from insufficient stretching, tenotomies and open division of the resisting fasciæ and muscles are first in order. The fascia lata, the abductors, the hamstrings, and the ilio-psoas may each be too short. The tendon of the adductor magnus exerts a strong force to oppose drawing the femur down. A small incision a finger's breadth above the upper border of the tubercle on the internal condyle of the femur exposes the tendon under the fascia lata where it is readily isolated, lifted on the director, and cut. Open division is preferable for the hamstrings and ilio-psoas tendons also.

**Bloody Reductions, or Reductions by Free Incision and Dissection.**—Hoffa originally used the posterior incision Langenbeck employed for excision of the hip dividing from their attachments all the muscles inserted in the trochanter major.

Today the operator aims to lay open the capsule by the shortest route which gives a clear view of its interior, to replace the head in its socket and to stitch the capsule so as to retain it in place, doing as little cutting as possible to the muscles, but stretching them as thoroughly as possible before beginning the cutting method. The machine stretching is a handy adjuvant.

Bradford's incision is made along the anterior border of the tensor vaginæ femoris muscle and between it and the front border of the gluteus medius leading by a short dissection to the tendinous origin of the rectus femoris at the anterior inferior spine; leaving these on the outer side one comes immediately upon the capsule; strong retraction will give ample room if the skin incision be large enough, or a short cross incision can be added to give more space. By flexing and ro-

tating the thigh the capsule may be cut in two, leaving a short cuff on the femoral neck and a long one on the pelvis; the femoral neck is rotated outward and forward, and retracted so as to turn the head and neck out of the way and allow unobstructed examination of the interior of the pelvic part of the capsule; this may be facilitated by retracting the edge of the cuff with a couple of silk sutures in its upper and lower anterior border. The ilio-psoas may need to be drawn aside and rarely it may have to be cut before a good view of the interior of the capsule can be had. A small channel is looked for at the apparent bottom leading inward, forward and downward around a corner into the real acetabulum; the finger, though often too large to penetrate, will detect a sharp edge or hymen of capsule which is easily divided with a small scalpel, then the finger penetrates and explores by touch so as to ascertain what the acetabulum is like and whether the head is liable to stay in it, and incidentally if the capsule has been divided sufficiently to let the head pass. In order to avoid risk of folding the capsule into the cavity in front of the head a small retractor or a little Sim's speculum is put into the acetabulum along the upper part of the cuff of capsule and serves like a shoe-horn to guide the femoral head as one manipulates it carefully down into the socket.

Next, one tests the readiness to redislocate in different positions of the thigh; sometimes the Y ligament of Bigelow prevents bringing the limb down from flexion; by a little care it can be exposed, divided by a Z-shaped cut as in lengthening tendons. It is a good plan to place a stout double-silk suture through the toughest part of the capsule at the lower border of its pelvic attachment, a double suture, tying one suture around the neck and the other around the shaft at the base of the great trochanter, both passing close to the bone. The pelvic cuff of capsule is too large, it may be cut in the line of the neck to permit overlapping or it may be "gathered" and stitched to itself and to the edge of the femoral part. A small gutta percha wick may be left in the joint emerging from the low angle of the incision to be slipped out at the first dressing if there be no infection; the skin and fascia are sutured separately. A small dressing of sterilized gauze is applied so as to be readily changed as a

window dressing subsequently. Plaster bandages are then put on as one would after a bloodless reduction. The position for retention must be one whose stability has been tested; it should also place the axis of the neck in a nearly horizontal plane in both standing or lying attitude. It is not often necessary to use abduction beyond ninety degrees.

When there is great disparity between the form of the head and socket one may pare down the head or one may scoop out the socket, bearing in mind that if articular cartilage be taken from both sides of the joint there is more chance of ankylosis.

The strictest asepsis is to be maintained in operating and dressing; the dissection is greatly simplified if all bleeding points are immediately stopped by forceps-pressure or twisting, leaving a clean dry wound and avoiding blunt dissection. Proof of reduction should be sought by a radiographic plate after operation, taken through the plaster bandage.

If the deep retaining sutures have been firmly placed and tightly tied the danger of redislocation is little and early walking on crutches is encouraged; early weight-bearing must depend upon the amount of resistance to dislocating at time it was reduced; early walking undoubtedly favors recovery with motion, but it may add to the risk of redislocation.

Plaster-of-Paris bandage after reduction by incision, usually need not be continued more than three months, one month without weight-bearing on crutches, one month using the foot a little in the original plaster, and the third month in a straightened position in plaster gradually increasing the amount of weight-bearing; that is if the solidity of the joint is good at the close of the operation. When plaster is discarded exercise should be much restricted at first, gradually increasing from day to day both the amount of weight borne on the limb and the amount of motion at the hip. There should be a prescribed set of daily exercises designed to restore mobility and strength lost by prolonged immobilization.

**Anterior Transposition of the Hip.**—Lorenz has designated, under the term anterior transposition of the hip, changing a posterior into an anterior dislocation. It has been found of great service in

many cases because tipping of the pelvis and lordosis disappear if the body-weight be slung above instead of behind the acetabulum; shortening of course remains. It is of great use for relapsed cases and for those above the age limit. If consent to a cutting operation has not been given and the surgeon finds an unstable joint, he should place the hip in the anterior position. The usual manipulations for stretching and reducing having been previously performed, the thigh is grasped, flexed, rotated, and abducted so as to push the head into the space just above the socket, pressing strongly inward and rotating the thigh. If the head can be wedged under the long head of the rectus femoris muscle it is more liable to stay there permanently; a less good resting place is below the anterior spine under the sartorius and tensor vaginæ femoris. Sometimes this position of anterior transposition will slowly come of itself after what appeared to be a perfect anatomical reduction and in these cases the end result may be good, but not always is the ending so favorable. It depends on obtaining a secure and lasting anchorage on the ilium and failure to obtain this means a return to the dorsal dislocation with its deformity and disabling gait.

**Summary.**—In summing up the different forms of treatment one is struck with the progressive improvements which have come forward in a short space of time. It is too early to know comparative merits, end results are still disappointing in many cases, yet in it all there is the bright promise of future success, and the discouraging failures of today will undoubtedly teach one to do better. Has not the same process of evolution been seen in the treatment of club-foot? Nobody today regards club-foot as incurable at any age, yet how often since the days of Scarpa has the promise been made that the latest method would cure every club-foot? Are there not today a number of methods in use more or less indispensable if one would have all club-feet cured?

A safe routine to follow in the choice of operative methods would be the following: Do not operate to reduce congenital dislocation until the age of diapers is passed on account of the plaster bandages; children under five years of age have the best chance of a successful bloodless reduction by manipulation only; older ones by the

machine reduction. All cases which have relapsed, unless a safe anterior transposition exists, and all cases which at the time of reduction fail to show a satisfactory resistance to redislocation should undergo the cutting operation after a thorough stretching. Failure after manipulation may sometimes be converted into success by dividing some resisting structure like the tendon of the adductor magnus, the front of the fascia lata or the hamstrings which had failed to yield to manual or mechanical force. Excavation of the acetabulum and trimming the femoral head are only needed to correct considerable disparity in the form or size of head and socket. Deepening the acetabulum was used by Baer in his successful adult case, and is extensively used by many operators like Hoffa; its only drawback is the chance of ankylosis.

## CHAPTER V.

# CONGENITAL LUXATIONS CONCLUDED; SUBLUXATIONS OF HIP, KNEE, AND OTHER JOINTS.

### CONGENITAL SUBLUXATION OF THE HIP.

**Congenital subluxations** of two kinds have been described. In one there is a displacement of the joint upward which may be demonstrated by the X-ray showing a difference in the level of the two hips with shortening usually of less than an inch and a slight limp. They resemble coxa vara only the angle of the neck of the femur is normal, the whole joint too high, as if the acetabulum had migrated upward from cause unknown. In the other, an infant or child has the power of voluntarily displacing the femoral head up onto the rim of the socket and reducing it with a snap; it is called snapping-hip. It occurs on semi-flexing the thigh and adducting it, and is particularly apt to be done by a baby in a fit of temper. I have seen it recently in a girl of eleven who could do it at will on either hip when standing in her natural attitude. Immobilizing as much as one can in a plaster-of Paris spica has been tried with varying success; as it gives no trouble, it is usually disregarded and supposedly outgrown.

### CONGENITAL DISLOCATION OF THE KNEE.

**Congenital dislocation** of the knee is not very rare; it is hereditary and three in a family have had it; it is usually a displacement forward of the tibia on the femoral condyles; it is called *genu recurvatum*, when the tibia makes an angle approaching a right angle with the femur; but it is a very common thing for young and old to exhibit knees which bend somewhat back, and it is not rare to find them bending forty-five degrees in this direction. A right

angled deformity shows the prominence of the knee directed backward so that the condyles of the femur can be plainly seen and felt, lateral motion is often present to a slight amount; there is general laxity of joint and the patella may be small or absent. Alterations in the form of the bones, cartilages, and ligaments have been described and ankylosis may occur rarely. In babies treatment aims to permit normal motion in the joint, and to prevent the use of the limb in abnormal positions, trusting that nature will gradually shorten the ligaments and muscles which limit normal motion. Children who walk should wear a light double upright knee and ankle jointed apparatus designed to prevent all lateral motion and prevent hyperextension of the knee, allowing it perfect freedom to extend and flex almost to the normal limit. Gymnastic exercises are given to strengthen and develop the hamstring muscles; their use diminishes the time of splint wearing. Bacilieri points out the ease of correction in the first days of life; he considers hyperextension is not the result of the quadriceps' pull but comes from the faulty action of the biceps, the insertion being too far forward, so that it extends instead of flexing the knee.

## CONGENITAL SUBLUXATION OF THE KNEE.

Three forms are found in the knee-joint—congenital backward subluxation, lateral dislocation, and dislocation of the patella. The first is very rare; for its treatment the reader is referred to p. 8.

Lateral dislocation, or snapping knee, is uncommon. Two cases were described by the writer in 1898. Both were in the neighborhood of a year old and could voluntarily snap the knee out in the semi-flexed position; it did not hinder walking, there was free lateral tilting and sliding of the knee, and in position of semi-flexion there would sometimes come a sudden snap when the inner femoral condyle became very prominent the shin was no longer in line with the thigh; on palpation one felt that the internal condyle of the tibial head was against the external femoral condyle. The dislocation occurs because all the ligaments of the knee are too long to resist the outward pull of the popliteus muscle in a flexed knee.

**Treatment.**—Treatment is directed to the prevention of abnormal movements by the appliance described on page 61.

**Congenital dislocation of the patella** has often been described and some regard all cases of habitual slipping patella as of antenatal origin; the writer believes some cases to be due to congenital misinsertion of the ligamentum patellæ; but most come from knock-knee with an unnaturally long patellar ligament. It is primarily due to lax ligaments, weakness of the vasti, and too long a ligamentum patellæ. Three forms are described, outward, inward, and upward displacements; the only common one is the outward displacement with knock-knee; a very long patella tendon produces the upward form. The amount of impairment of extension dedepends on the insertion of the patellar ligament. If it be into the tubercle of the tibia all is well, if off on one side of it, it will slip and become misplaced, and if its insertion be into capsule and fascia it will utterly fail to extend the leg. Treatment should aim to restore lost function and to prevent habitual dislocation. There is no fixed rule. The surgeon has to study the amount of disability and the exact anatomical condition which confronts him. Palliative measures, elastic knee-caps and the jointed splint with springs pressing on the sides of the knee pan are often of use. If they fa'l the form of operation must vary to suit the condition.

Goldthwait has operated by changing the insertion of the patellar tendon inward so as to bring the line of pull straight. Most patellæ dislocate outward and occur in girls with long patellar tendons. A vertical incision is made from the tibial tubercle upward through which the whole patellar tendon is exposed and split in two vertically; the outer half separated from the tibia is passed under the inner portion and firmly sutured under the periosteum. This gives a straight line of pull.

**Congenital Dislocation of the Ankle.**—It has been described under absence of the tibia and of the fibula, pages 8 and 9.

## CONGENITAL DISLOCATION OF THE SHOULDER.

They are not rare if one includes those due to obstetric paralysis; congenital non-paralytic dislocations are decidedly uncommon.

That it exists cannot be doubted. Autopsies of a fetus of eight months and of a child of three days have been described in detail where no glenoid cavity was found. Many of the dislocations reported as congenital are due to obstetrical paralysis, that is paralysis produced by rupture or crush of a part of the brachial plexus at birth. This form of paralysis will be considered on page 78.

Pure congenital dislocations may be subspinous, subcoracoid or subacromial, and are rare in little children without paralysis. Whitman has obtained a reduction by manipulations under ether, stretching the tissues as in the bloodless reduction of congenital dislocation of the hip. After reduction the arm was fixed in plaster for months in the attitude of extension on the scapula to force the head of the humerus forward and in outward rotation to overcome the tendency to rotate inward. A long period of exercises followed this period of fixation. Phelps, of New York, described an operation for subspinous luxation, which he had used on three patients. A posterior incision along the margin of the deltoid opened the joint; on account of the small size of the imperfect glenoid cavity part of the head of the humerus had to be cut away and the redundant posterior portion of the capsule was excised; after reduction the posterior part of the capsule was tightened up by sutures to prevent the head falling backward into the old position, and the arm was fixed in plaster-of-Paris bandage; the immediate result was good.

## CONGENITAL DISLOCATION OF THE ELBOW.

But few cases are known and different conditions described. Both bones of forearm may be displaced forward or backward, a backward displacement of the radius with a subluxation of the ulna and absence of the external condyle, and a dislocation of the radial head alone have all been noted in literature. At times there is no disability, at other times the head of the radius or the entire elbow have to be resected.

Blodgett, of Detroit, analyzed fifty-one cases of congenital luxation of the head of the radius. It is about twice as common in the male and as often double as single ; forty-six percent were dislocated

backward, forty forward, twelve outward, and two percent inward. In a third of them there was a bony fusion of the upper ends of the bones of the forearm. A condition similar to congenital dislocation has been attributed to syphilis by Cotton and Bottomley and Ambard. Congenital dislocation of the elbow is hereditary, seven cases are reported in four generations of one family by Abbott.

The condition should be studied with radiographs; they are a great aid to more precise anatomical diagnosis, together with careful palpation. Burrell recently divided the line between upper fused ends of the radius and ulna in such a case, but they grew together again.

## CONGENITAL DISLOCATION OF THE WRIST.

The condition has been considered under club-hand, p. 4. It is rare without a defect of the radius or ulna.

Subluxation of the wrist, the wrist and hand being in front of the line of the forearm, has been attributed to congenital laxity of the joint from long ligaments, also to rickets years before. Little evidence of its congenital origin exists. Replacing and holding the hand in extension for many months in a splint or leather appliance with massage and graded exercises has been the treatment.

## CHAPTER VI.

# DISEASES CAUSING DEFORMITY WHICH ORIGINATE BEFORE BIRTH.

## FETAL SYPHILIS.

Fetal syphilis is known to exist and frequently leads to the death of the fetus. This affection in and about the joints of the new-born has been described by Parrot as an osteochondritis, characterized by irregular enlargements of the epiphyses of the long bones which seem to encroach upon the shaft and enclose it, as it were, in a cup. Marfan recently called attention to the frequency of suppurative disease of such joints in the early weeks of life, resulting quite often in ankylosis. The periosteum is thickened and the shaft considerably enlarged. (See Chapter XI.) Separation of the epiphyses is said to be common and may cause a pseudo-paralysis. Further consideration of bone syphilis will be found on page 203.

## CONGENITAL TUBERCULOSIS.

Congenital tuberculosis occurs in cattle, sheep, horses, and possibly in man. Human infants in the early weeks of life are occasionally observed with a cold abscess about the hip or knee, which in older children would take a month or more to form. The writer has drained several of these and in each instance no organisms were found in the pus. Whether they were tuberculous or whether the joint disease from which they started was tuberculous, it was impossible to say.

## FETAL RICKETS.

The existence of congenital rickets has been a matter of dispute for many years. The trend of opinion today is against it. Syphilis,

chondrodystrophia fetalis, and osteogenesis imperfecta can be made to explain what was formerly called fetal rickets.

## ACHONDROPLASIA.

Chondrodystrophia fetalis or achondroplasia is an affection somewhat like cretinism and rickets. It dwarfs the individual by preventing the growth of the arms and legs while the trunk continues to grow. The infants at birth are said to show signs of severe rickets with short arms and legs, a large head, depression of the root of the nose, beading of the ribs, flattening of the sides of the chest, and enlargements at the wrists and ankles. The affection, however, is pathologically distinct from rickets. It begins between the third and fifth month of intrauterine life; as growth goes on, the short arms and legs are in strong contrast with the length of the trunk. Mild cases grow to adult life as bow-legged dwarfs, but many are still-born or live a few weeks.

FIG. 37.—Chondrodystrophia fetalis. (*Children's Hospital.*)

Müller, in 1860, showed that it differed from rickets and cretinism in having very little proliferation of the cartilages of the epiphyses. Of course if the epiphyseal cartilage does not proliferate a long bone cannot lengthen.

## OSTEOGENESIS IMPERFECTA.

Osteogenesis imperfecta, congenital brittle bone. This affection is a general one of all the bones of the body and is characterized by multiple fractures occurring before, during and after birth in infants otherwise healthy and well formed. The fractures are often painless and are often produced spontaneously by the

action of the infant's muscles. The nature of the affection is unknown. These infants seldom live over a year. It is, fortunately, uncommon.

FIG. 38.—Chondrodystrophia fetalis, short bones the shaft wide where it joins the epiphysis which is small. (*R. W. George, Radiographer.*)

Brittle bones are hereditary in 15 percent of the cases, in some instances involving an entire family, an instance of which is described by Willard, of Philadelphia; among 7 daughters, 6 sustained from one to four fractures, and of 3 sons, all had suffered from one to four early fractures, while one grandchild had two fractures in four weeks. In some families, it appears among brothers and sisters where the tendency in the family has not been shown previously; and once the affection was reported in 2 cousins. Those born with one or two intrauterine fractures are likely to live for a while but most babies who come into the world with many fractures are dead born. Intrauterine fractures are usually accompanied by fresh fractures produced during birth; these usually unite quickly, but in some, union takes place slowly and a few do not unite; the callus is often small, and crepitus is slight, they are painless. The thighs are most often broken, followed by

the legs, and the long bones of the upper extremity; but the clavicles, ribs, and the lower jaw, may be broken. Other congenital deformities seldom accompany the condition, but hydrocephalus and club-foot have been observed. The deformities produced by the disease may be due to fractures united with improper alignment, or a bending of the bones may be present due to the disease itself independent of fracture, a bending analogous to rickets, osteomalacia, and achondroplasia. Forward bending of the tibia, forward and outward bending of the femur, outward bending of the humerus, and distortion of the pelvis have been reported; scoliosis has been observed.

The children are usually smaller than the average at birth and the extremities are sometimes abnormally short in proportion to the trunk. The skin is normal or thin, not thick and edematous; the cretinoid type of face has rarely been alluded to; but the cranium is imperfectly ossified; and all bones cast a feeble X-ray shadow and are thin and atrophic, for the medullary cavity seems to be increased at the expense of the cortex. The epiphyseal lines are sharp but are less regular than normal; both fractures and infractions may be shown by the X-ray. Microscopic section of the spongy bone shows the trabeculæ with imperfect bony lamination and imperfect bone corpuscles which are oval, not stellate, and there are no canaliculæ between the lacunæ; on the surface of the trabeculæ are some osteoblasts and the bone marrow is apparently normal. At the epiphyseal line, the zone of proliferation is almost absent and the zone of hypertrophy very little developed, although the cartilage cells are arranged in regular columns separated by strands of hyaline matrix; the line of provisional calcification cannot be made out. The primary trabeculæ are composed largely of persistent cartilage cells in a matrix containing a few granules of lime; they are beset by too few osteoblasts but farther from the epiphysis osteoblasts are present almost as in normal bone; the marrow near the epiphysis may be edematous or myxomatous.

Brittle bones is a general term used to describe any condition when people's bones break with little provocation. Osteogenesis imperfecta is not the only affection in which brittleness of the bones

has been observed; early fractures occur also in chondodystrophia fetalis, in syphilitic bone disease, and in some early cases of rickets; it occurs also in osteomalacia of childhood; in senile atrophy or osteoporosis, in inflammatory diseases, as osteomyelitis, tuberculosis neural arthropathy of tabes, syringomyelia, in paralysis, in malignant tumers of the bones, and in bone cysts. Brittle bones without known cause also occur in little children who later outgrow the condition.

No satisfactory treatment of osteogenesis imperfecta has been formulated. In a recent fatal case reported by Lovett and Nichols, the child was kept upon a pillow, not handled or allowed to sit up, and the clothing arranged so as to disturb him as little as possible in changing it; but in spite of every precaution, ten partial or complete fractures occurred before he was five months old.

## DEFORMITIES DUE TO DISEASES OF THE NERVOUS SYSTEM OF FETAL OR INTERPARTAL ORIGIN.

### SPINA BIFIDA.

**Paralytic Distortions from Spina Bifida.**—Many spinæ bifidæ have club-feet, club-hands, distortions of the hip or knee, hernia, in fact, all sorts of malformations. Usually one finds a paralysis of the leg with the club-foot, and sometimes a loss of sensation and trophic changes in the skin; even trophic ulcers of the skin have been observed. The same sort of paralysis and deformity accompanies spina bifida occulta, and its origin may pass unnoticed until some day the back is examined and the peculiar local growth of hair is found.

Of the club-feet associated with spina bifida, some are true congenital club-feet, many are due to paralysis. Unfortunately, operating on the sac has seldom benefited the paralysis. Treatment, therefore, aims to restore the function of the foot either by the use of a mechanical apparatus, or by a conservative operation, like a tendon transference. The apparatus must vary with the individual case, and must be very light for the limb is weak. The club-

foot shoe for equino-varus, or the sole plate for valgus, or the short caliper splint with a stop for simple toe drop, all these may be of service (see Chapter XXI). Exercises, manipulation and massage should be persevered in.

The indications for these conservative operations are the same as for long standing infantile paralysis, but one must heed the presence of extensive trophic disturbances. Tendon transplantation,

FIG. 39.—Spina bifida two months after operation, hydrocephalus and club-foot. (*Infant's Hospital.*)

tendon shortening, and arthrodesis of the ankle-joint may be advisable.

Kirmisson reports a successful Pirogoff's amputation done on a young man with equino valgus to get rid of constantly recurring trophic ulcers.

For a description of operations for paralytic club-foot see Chapter XIX.

## HEREDITARY ATAXIA OR FRIEDREICH'S DISEASE.

According to Déjérine and Letulle, this affection is produced by a gliomatous growth originating in an imperfectly developed central canal of the cord. It is therefore considered as a disease of fetal origin.

It is an affection of childhood, resembling in many respects locomotor ataxia, and oftenest occurs among brothers and sisters but it may be inherited. Both sexes are attacked.

In the cord there is a sclerosis of the posterior columns, degeneration of the lateral columns, and the central canal of the cord is altered into an irregular mass or masses of various shaped cells stringing out into the surrounding gray matter with degeneration of the columns of Goll and Burdach, and degeneration of the posterior roots. It is a neuroglious sclerosis, "A gliosis of the posterior columns due to developmental error."

Clinically, the child has an ataxic gait without the lightning pains and crises of locomotor ataxia and without the Argyll-Robertson pupil. The knee jerk disappears, incoordinate movements begin in the legs, spread to the arms, neck, and head; lateral curvature of the spine, talipes valgus and flexion of the knees are common accompaniments.

Robbins, of Washington, D.C., recently summarized a hundred cases from medical literature, of whom 47 had deformed feet, and 48 lateral curvature of the spine, usually the right dorsal convex; speech was affected in 70.

The affection though progressive, may last as long as 30 years and is incurable. Symptomatic treatment for the lateral curvature of the spine and distortions of the limbs should be employed.

## PROGRESSIVE MUSCULAR ATROPHIES.

**Progressive Muscular Atrophies, the Dystrophies.**—This group of affections in childhood is inherited, and is, therefore, included here. In the adult other causes for it are found.

**The Aran-Duchenne type** is comparatively common in adults over 25 years old associated with atrophy of the anterior horns of the gray matter of the cord; but very few children have been known to have it. Hoffmann reports a brother and sister in whom the disease began at 4 years of age.

The symptoms are ill-defined pains with loss of power and atrophy of the hand. Both the thenar and hyptohenar eminences of the palm of the hand become atrophied and sunken; the interossei and lumbricales shrivel, leaving depressions between the metacarpals; then the wasting spreads to the flexors and ex-

tensors of the forearm, a contraction sets in, claw-hand developes, and the deltoid atrophies. Then the remaining muscles of the upper extremity, those of the trunk, and of the lower limb atrophy. This order is not always adhered to, but is unusual for the legs to atrophy early soon after the process commences in the hand. Sensation is not disturbed. The disease progresses slowly and is incurable.

**The peroneal or leg type** is hereditary or a family affection, beginning in very early life or not later than 20 years. It is associated with degenerative changes in those peripheral nerves which supply motion to the feet and hands. But the spinal cord shows no lesions. In the muscles the transverse striations are diminished and the nuclei increased. The peroneal muscles and the intrinsic muscles of the feet first develop atrophy and weakness; either talipes equinus or equino-varus is produced by the contraction of unantagonized muscles. In time the whole leg atrophies, but the upper extremity and body are affected late in the disease. Fibrillary contractions of the muscles are visible, electrical reactions are diminished or absent, the knee jerk is absent; sensation may be slightly impaired, and hyperesthesia has been noted. The disease progresses very slowly. There are often long periods without change, but it is incurable.

By correcting the club-foot, locomotion may be maintained, which adds to the general health of the patient. This may be accomplished by mechanical or surgical means. (See Chapter XIX.) Massage and electricity prevent stiffness and seem to retard the progress of atrophy.

The progressive muscular atrophy of the Aran-Duchenne type is associated, as we have seen, with lesions of the cord, the peroneal type with degenerative changes of the motor nerves supplying the hands and feet without cord lesions.

The following atrophies or dystrophies of the muscles, though they closely resemble the preceding in many respects, are without discoverable lesion of the brain, cord, or nerves. They fall into three types: The juvenile muscular atrophy of Erb, face and shoulder atrophy of Landouzy and pseudo-muscular hypertrophy.

They are hereditary or are seen among brothers and sisters.

Although in pseudo-muscular hypertrophy the limb shows increased size instead of a diminution, the muscle itself microscopically shows atrophy, for between the bundles of muscle fibres, the fibrous tissue is greatly increased and infiltrated with fat. The electric reactions of such muscles are diminished, but the reaction of degeneration is never present.

**Erb's Juvenile Atrophy.**—This is a disease of late childhood and youth, attacking girls usually. The angel-wing deformity from paralysis of the serratus magnus is common early in the disease, but the pectorals, trapezius, rhomboid, latissimus dorsi, and triceps become weak and atrophy; then muscles weaken and atrophy in the lower back and thigh, but the leg below the knee is one of the last places involved. Talipes arising from unbalanced muscle-antagonism is of the equino-varus or equino-valgus type. There is weakness but no true paralysis of the muscles. The calf muscles are the very last to be affected and the forearm and hand escape. Weakness with an enlargement instead of atrophy has been seen occasionally in the deltoid and the muscles about the scapula. The progress of the disease is very slow—it has lasted 40 years. Symptoms of bulbar paralysis seldom occur but atrophy and weakness of the muscles of respiration, especially the diaphragm, have caused death.

Like the other forms, it is incurable; mechanical appliances and tendon transferences may be used for the correction of club-feet and other distortions.

**Landouzy-Déjérine or Face and Shoulder Type of Muscular Dystrophy.**—This type of muscular atrophy differs only in that the face is first involved. The expression is dull and flaccid, the lips puffy, and later, the shoulders, arms, back, and legs undergo the same changes as in the preceding form.

Westphal describes a case of typical pseudo-muscular hypertrophy in which the muscles of the face were involved early just like this Landouzy-Déjérine form. The ocular muscles and muscles of mastication are never affected.

**Pseudo-Muscular Hypertrophy.**—Pseudo-muscular hypertrophy is by no means an uncommon frequenter of orthopedic clinics. Boys usually from 5 to 10 years of age are attacked by it;

it is steadily progressive and incurable. It may be recognized at a glance by the association of a magnificent development of the calf of the leg combined with so much weakness that the boy cannot rise without climbing up on himself as in Fig. 40. It has been known to begin in infancy; in that case, the boy learned to walk late and helped himself along by leaning on chairs, etc. There is no disturbance of sensation or of the function of the bladder and rectum. The weakness begins in the legs, extends later to the back, shoulders and arms; muscular antagonism may become unbalanced through unequal distribution of weakness, producing flexion at the hips and knees, talipes equinus, round shoulders, and lateral curvature of the spine. The gait indicates weakness, a shuffling gait; there is difficulty in walking up stairs, falls are frequent. Sometimes the gait is rolling, as the boy throws his body-weight alternately on each hip to economize effort.

FIG. 40.—Climbing up on himself in pseudo-muscular hypertrophy.

So far treatment is only palliative, and on account of weakness, apparatus usually fails to improve locomotion. When power is lost, a go-cart, plenty of fresh air, massage, and resistive exercises assist in maintaining general health. In a case where contraction of the calf muscles produced talipes equinus, tenotomy of the tendo Achillis sufficed to restore the power of locomotion for many months. Straightening the knees by dividing contracted hamstrings has also been of advantage.

In the British Medical Journal, for 1882, may be found an account of the only recorded recovery from pseudo-muscular hypertrophy.

## SPASTIC PARALYSIS.

**Spastic Paralysis, Little's Disease, Cerebral Palsies of Infancy.** —Spastic paralysis is characterized by an increased excitability of

the reflexes, and stiffening, a more or less tonic contraction of the weakened muscles. The paralysis may have the following distribution: hemiplegia, diplegia, paraplegia, or monoplegia; therefore it is of cerebral origin. Autopsies are uncommon, but they have demonstrated a large loss of brain, either on the surface or interior, supposedly from an extensive old hemorrhage. In many there is a loss of a large part of a lobe from the external pressure of hemorrhage from a meningeal artery. In many the intelligence is impaired in varying degree from a grave idiocy to slight backwardness. Most are due to the cerebral hemorrhages of parturition, but some acquire the palsy in childhood from hemorrhage, thrombosis, embolism, or during the course of some acute infectious disease.

Spastic paralysis is not uncommon and the prognosis is not good and is less encouraging with the greater degrees of mental impairment.

**Physical Signs.**—The condition, when the child is brought to the orthopedist, is not a true paralysis of motion; the affected limbs are relaxed during sleep but at other times they are held awkwardly and attempts to use them or to give sudden passive movements evoke an incoordinate resistance, which yields to slow pressure of the hand. It is called spastic rigidity.

Muscular atrophy is inconspicuous, but there are often distortions of the limbs from continually holding them in peculiar attitudes, and if of long standing the tissues may shorten so as to prevent a full range of motion of the joints. There is marked weakness. The knee-jerk is very lively and ankle-clonus easily started in the affected leg; in the arm a reflex like a knee jerk may sometimes be obtained by tapping the triceps tendon just above the olecranon, and similar contractions by flicking with the finger over the bellies or tendons of affected muscles.

Although all grades of idiocy accompany this affection, in some the mind is clear, and this influences prognosis, for it is useless to tenotomize and instruct in walking if the brain to use the feet be lacking; on the other hand children have been greatly improved mentally after walking was made possible, so the question of tenotomy may be a hard one to decide. Epilepsy comes on in a number of them in adolescence; athetoid movements may also be present.

**Treatment** is divided into muscle training, muscle division, and muscle transference. In a paraplegic the muscles which contract and interfere with locomotion are usually the adductors and the gastrocnemius and soleus, producing a cross-legged gait with the heel raised and a clonus of the calf muscle, a condition which is relieved by strengthening the opposing muscles in a mild case, or by dividing the tendons, immobiliz'ng for a few weeks and using a walking retentive splint in severe ones. For the mild case such exercises as these: Lying on the back and straddling, this is done at first without resistance, later with a light weight attached to the ankle by a cord passing over the side of the table; turning the toes out may be taught by placing the heels together and repeatedly rotating the feet with the body and legs in the same position; toe-raising can be learned by slow and repeated attempts, at first aided with the hand. Exercises are of no use, however, if the spastic rigidity be great or if there be much mental impairment.

Tenotomy of the tendo Achillis and plantar fascia has been of great benefit in curing the equino-varus deformity and is done exactly as for club-foot, see p. 29. Care must be had not to overcorrect much in the plaster bandage, which should be about at a right angle and should be worn two weeks and replaced by a walking apparatus which prevents toe-drop. Walking should begin at once and requires careful, patient teaching.

Division of the adductors is best done by free open incision over the belly of the adductor longus made tense by abducting, giving a wide berth to vessels and nerves; it is advisable to excise a piece of muscle about two inches long to prevent reshortening and part of the adductor magnus may be removed by the same incision, that is the upper portion for the tendon of the latter is divided through a small separate incision a finger's breadth above the tubercle on the internal condyle of the femur. Much is gained by forcible stretching in abduction, branches of the deep external pudic artery and the internal circumflex branch of the profunda femoris may require ligature, and muscular branches. After applying a superficial suture and dressing, the leg is kept in a double

spica bandage of plaster-of-Paris in extreme abduction for a month.

Muscle-stretching under full anæsthesia followed by fixation in plaster may be used for mild cases; the plaster bandage is to be worn three weeks and when removed it is a good plan to keep the feet apart with a short rod a foot or fifteen inches long loosely attached at each end to the ankles, and to wear the old plaster at night; and exercises must be persevered in.

For the arm in hemiplegics muscle-stretching under anæsthesia and myotomies have produced improvement, and in mild cases simple muscle-training has helped; this must form the essential part of the aftercure when fixation in plaster is finished. Better ultimate results have been obtained by tendon transference, however, and a number of different things have been done.

**Muscle Transference.**—To correct incomplete extension of the knee, the sartorius has been transplanted into the tendon of the quadriceps extensor, also both sartorius and gracilis; these are not strong enough to give extension at first, but as Goldthwait has demonstrated they may grow strong with use. The hamstrings may be transferred forward; that is, the insertion of the biceps may be moved from the head of the fibula to the outer side of the quadriceps tendon, and the tendon of the semi-tendinosus into its inner border; this, of course, deprives the limb of part of its power of flexion and should be reserved for severe cases, with good hamstrings.

In the forearm and wrist two operations have proved of value.

Inability to supinate the hand may be improved by converting the pronator radii teres into a supinator, the operation is known as Tubby's operation. A four inch incision is made in the centre of the flexor surface of the forearm and the inner border of the supinator longus, reflected outward, exposes the belly and insertion of the pronator teres; this is divided at its insertion into the outer side of the radius and a silk guide-stitch is placed in the upper end; the dissection is continued close to the radius through the interosseous membrane, then a second incision is made on the dorsum opposite the first so as to reflect the extensors carpi radialis brevior and longior towards the supinator longus, exposing the supinator

brevis whose lower edge is freed to lay bare the radial origin of the extensor ossis metacarpi pollicis and the radius itself and expose the opening in the interosseous membrane made anteriorly; the silk guide-stitch is then passed through this opening and the pronator sutured to the outer side of the radius close to its old attachment; it then supinates instead of pronating. Supination is to be maintained in plaster for at least six weeks to get a firm union; a subperiosteal insertion may be better attachment than a periosteal one.

For wrist-drop the flexor carpi radialis is cut at the wrist and attached to the tendon of the radial extensor close to its insertion and a similar transfer is made on the ulnar side.

These operations may be done at the same sitting. After immobilizing six weeks in plaster, great care and pains must be taken with muscle-training exercises. Skilled use of the hands in agreeable work does much to prevent relapse, which is sometimes traced to discouragement and lack of use. Mild grades of feeble-mindedness may prevent good use of the hand.

## OBSTETRICAL PARALYSIS.

This form of paralysis is produced at the time of delivery by undue stretching of the brachial plexus or by pinching it between the clavicle and first rib. Prout studied these lesions excised at operation and showed that a "rupture of the perineural sheath takes place with hemorrhage into its substance." The amount of tearing apart of nerve bundles from hemorrhage varies and with it the prognosis for spontaneous recovery. Where there is stretching and small hemorrhage rather than a tearing asunder the paralysis will be transitory, and improvement may be expected.

The affection was first described by Duchenne twenty-five years ago. There are three types of the paralysis, as different parts of the plexus are affected. These types are recogn'zed by peculiar positions of the arm, due to the nerve distribution. The types are the upper arm, the lower arm type, and paralysis of the whole arm.

In the upper arm type, the conductivity of the fifth and sixth cervical nerves is interfered with, either by pressure or section, and the injury is either in the cords of the plexus or above it close to the intervertebral foramen. In this type muscles of the shoulder and upper arm are involved, the shoulder may be dislocated, but the forearm almost escapes.

Bullard, in 43 cases at the Children's Hospital, found an involvement of the deltoid, biceps, brachialis anticus, supinator longus, supinator brevis, infra-spinatus, serratus magnus, coraco-brachialis, and teres major and minor.

The arm hangs by the side in the position of inward rotation; the grasp is unimpaired; the hand supinates only half way; flexion at the elbow is weak, extension is not affected; the patient cannot raise the arm from the side nor rotate it outwardly; inward rotation is weak because the limb is held fixed in almost as much inward rotation as is possible; passive movements are free. This position is due to lack of antagonism and depends on three factors, inward rotation of the arm, extension of the forearm, and the weight of the hanging arm.

In addition to the paralysis there may be adhesions around the scapula and adhesions to the capsule of the joint, or within the capsule.

There is a shortening of the whole limb, and adhesions in the elbow-joint may prevent complete supination. Dislocation of the head of the humerus is common, and the shoulder may be luxated forward or backward for which the pectoralis major or latissimus dorsi is largely responsible. A dislocation may occur in the elbow, or there is frequently loss of complete extension, where from 5 to 20 degrees of motion is lost. This may be due to several factors. One had a backward dislocation of the head of the radius, another an imperfect growth of the olecranon and upper end of the ulna which had not developed sufficiently to enter the olecranon fossa, in another, there was a partial lateral dislocation of the joint, in another, the bones of the whole extremity showed great atrophy and shortening, in another anterior subluxation of the radial head had occurred.

The lower arm type of paralysis, which is, however, rare, has

been described by J. J. Thomas. In it, most of the muscles of the shoulder and upper arm are active and well nourished, while those below the elbow are paralyzed.

In the third, or combined type of paralysis, there is more destruction of the cords of the plexus and paralysis of most of the muscles of the arm and shoulder. The condition is manifest immediately after birth although it may not be recognized for several days. The arm should be supported in a sling to prevent stretching the joint capsule and muscles.

**Treatment.**—Massage and electricity are of use in lighter cases. Joints should be exercised that no permanent contraction may take place. External rotation of the shoulder and supination are the most difficult motions to preserve. When paralysis affects only certain muscles, muscle transference may be used.

**Nerve Grafting or Suture.**—In a series of operations Clark, Taylor and Prout, of New York, restored voluntary power in three to five months after nerve suture in children as old as 8 and 10 years and in every one who survived there was some return of voluntary power.

In some cases it was possible to locate the lesion in a portion only of one of the nerve trunks going to the plexus, and in one of these cases the fifth cervical anterior primary division and the outer part of the combined trunk were resected and sutured, with excellent result.

Suture of the brachial plexus in the adult after stabs has seldom been performed and the return of voluntary power 8 and 10 years after birth was a surprise to many who thought that after 2 or 3 years, regeneration of a nerve trunk could not occur.

Spitzy, in July, 1905, operated on a boy of 12 years, with obstetrical paralysis of the left arm. The prominent symptoms were paralysis of the radial nerve, and, accordingly, the radial nerve was connected with the median nerve. A slip from the median nerve was inserted at the elbow into the radial, and the point protected from cicatricial growth by surrounding it with a sheath made from a dog's artery hardened in formalin. A light bandage maintained the flexed position of the elbow. In a week the wound had healed,

and in six weeks, light massage was begun. In two months slight movements were noticed extending the fingers and in six months almost all the extensor muscles had regained power.

Tubby has also transplanted the outer cord of the brachial plexus into the middle cord for paralysis of the Erb-Duchenne type.

In rare cases nature unaided brings about a cure late. Recovery of voluntary power may keep on slowly, almost imperceptibly, until complete or very nearly complete power returns to the arm. Sometimes the outward rotators of the humerus are not really paralyzed, but they are kept on the stretch by the powerful inward rotation of the pectoralis major and latissimus dorsi. Much benefit has been derived in a few instances by the open division of these strong tendons close to their insertions in the bicipital groove, and maintaining the arm in extreme outward rotation of the shoulder by means of the plaster bandage or wire splint. They should be divided thoroughly by open incision.

To restore the lost power to flex the elbow two slips from the triceps tendon may be brought forward and attached to the insertions of the biceps and brachialis anticus muscles. This seems worth trying although some say that one muscle cannot be innervated to pull separately on opposite sides of a joint.

**Jones' Operation.**—A different procedure has been done by Robert Jones. Aiming to maintain the flexed position of the elbow, he removed a diamond-shaped flap of skin from the bend of the elbow and sutured the edges so as to fix the elbow in a position of acute flexion, so that the hand can be of use for with the elbow extended it is almost useless. In two patients, aged 3 and 4 years, he found in less than 6 months after operation power was returning, and in less than 12 months restoration was almost complete.

# PART II.

## DEFORMITIES DUE TO BONE-GROWTH INFLUENCED BY EXTERNAL FORCES.

## CHAPTER VII.

# IRREGULAR SKULLS; LATERAL CURVATURE OF THE SPINE.

## IRREGULAR SKULLS.

**Influence of Gravitation.**—Babies are often brought to the orthopedist for a disproportion or asymmetry in the head; one side of the forehead is prominent, the other recedes, one ear is higher and slightly in front of the other, and if one looks down on the top of the head the shape is far from regular. This distortion is due to the action of gravity on the loose semi-membranous skull before the sutures ossify. If the babe is left lying in one position a flattening takes place at that part of the head which is pressing on the bed and a corresponding flat place diametrically opposite, while some bulging appears between. If the baby always lies in the same position this flattening and bulging little by little increases and all the cranial bones move slightly, including the orbit and the ear, so that the head becomes noticeably awry. The treatment is simply to have baby lie on the other side so as to press the bulging part in; and later to sleep on each side alternately; one is indeed fortunate if the deformity is corrected before synostosis has taken place, and the deformity becomes fixed. Even then a certain amount of correction occurs through subsequent growth. The irregular shapes of men's skulls may be seen at the hatter's, whose machine for fitting the hat to the head marks out an outline of the skull.

But this is not the only cause of irregularity in the shape of the skull; distortion and asymmetry arise from growth restricted by a short sterno-mastoid muscle in congenital torticollis (see Chapter XIX).

Anatomists have shown that any distortion of the neck or of the occipital portion of the skull is followed by a twist of the face. Pro-

fessor Dwight, of the Harvard Medical School, has studied in the Warren Museum the asymmetrical crania with the anomalies in the cervical spine and found that they may be divided into three classes: (1) Those associated with a diminution of the number of cervical vertebræ; (2) those with fused cervical vertebræ; (3) those associated with union of the atlas and occiput, either by fusion or by an intervening paramastoid process with or without fusion.

FIG. 41.—Skull showing irregular cranium. (*Warren Museum.*)

The cause of oblique growth of the skull and face is little understood. Dwight thinks any inequality in the level of the condyles of the occiput or the habitual advancement of one condyle ahead of the other may make the skull grow awry, for it brings into play a natural tendency of the body to correct an unbalanced condition. Suppose that anomalies in the cervical spine cause the head to look to the left, the right cheek is then more advanced and higher than the left; in order to look straight forward the head moves and the spine is twisted; little by little this twisting is taken up by the growth of the bones of the face and skull and in time a twist occurs in the skull so as to bring the left cheek farther forward and to direct the line of vision of the two eyes horizontally by a change in the direction

of the orbits; a similar change makes the line of the teeth horizontal and to accomplish this the direction of all the sockets in the jaws is altered. Still other factors are said to mould the face and skull into irregular shape. If one eye is very much better than the other it will instinctively be brought to a position where it can be used to more advantage, or a deaf ear may cause a displacement of the head and later compensatory change in shape through growth.

## LATERAL CURVATURE OF THE SPINE.

**Lateral curvature of the spine,** Scoliosis, in German Skoliosis, Seitlicher Ruckgratsverkrummung, in French, Déviation lateral la taille, Italian, Scoliosi, Spanish, Escoliosis, is a lateral deviation constantly maintained of the spinal column from the median sagittal plane of the body. It does not include mere postures, side bendings temporarily assumed or habitually taken which can be easily corrected by voluntary effort and have produced no structural change; these are called postural curvatures or mal-postures; their correction is of great importance for they may lead to true lateral curvature in time.

Lateral curvature is one of the commonest deformities; rarely seen at birth, but few are noticed before the seventh year when it becomes progressively more common, till fourteen, falls off steadily till eighteen, remains uncommon till twenty-two, and rarely develops after. Failure of parents to notice the beginnings leads one to the belief in an onset earlier in childhood. Recent investigations by Schulthess and Spitzy show that scoliosis is not uncommon in the florid stage of rickets (early childhood), and Böhm's radiographs of lateral curvatures show that a large proportion are of congenital origin, so that it is probably latent more commonly in early life than has been previously believed.

**Explanation of Descriptive Terms.**—Certain terms used in describing the deformities of lateral curvature need a word of explanation.

A deviation is present whenever the spine fails to run a straight and vertical course; a lateral deviation if it deviates to one side.

Inclination means that it leans or inclines to one side, or tips.

When the shoulders, instead of being over the base of the spine, are off to one side there is a lateral displacement.

Rotation is a term used in two senses, the anatomical and the clinical: anatomically it means a turning aside of the front of the vertebra from the straight forward direction it should face; clinically it is made to refer to the changed appearance of the back due to rotation, that is, to the prominence on one side and the flattening on the other caused by the ribs or transverse processes turning with the vertebræ and displacing the muscles of the back. The angle of rotation is the amount of this turning aside from the normal sagittal plane.

Torsion means twisting within the bony structure of a vertebra from distorted growth. In this country it has also been used in a clinical sense to mean that the line of the shoulder tips and that of the hips are not parallel as they should be, in other words that the shoulders are twisted on the hips, that if an imaginary line between the hips were projected upward vertically one shoulder would be back of it and the other in front. It seems better not to use the term in its clinical sense.

**Lateral Curves.**—In a spine there may be found one or more lateral curves, a condition spoken of as single, double, or treble curves; also called primary and secondary curves or simple and complicated. A curve may be sharp or flat, angular or bowed, long or short, and right or left (meaning convex to the right or left). In complicated curvatures each component curve has to take a direction different from the adjacent; e. g., a right curve with a left one or between two left ones. A single curve of the whole column may exist and be called a total curve. A curve may be according to location, cervical, cervico-dorsal, dorsal, dorso-lumbar, lumbar, lumbo-sacral, even slight sacral curves have been described. The normal physiological antero-posterior curvatures may or may not be affected by a lateral curvature; it may increase, diminish, obliterate, or reverse any normal or physiological curve, or it may not influence it at all. If a kyphotic deformity is the prominent feature, the curvature is called a kypho-scoliosis; it may be a right dorso-lumbar kypho-scoli-

osis, a left lumbo-dorsal lordo-scoliosis, etc. Clinically patients with lateral curvature are classed as the flexible and the stiff or structurally deformed. Schulthess has three clinical grades, first, those who can by voluntary effort straighten and correct the curve, second, those who can improve it, third, those who by their own efforts cannot improve their attitude.

**The Growth of the Physiological Curves of the Spine.**—The normal or physiological curves of the spine develop in childhood, for the infant at birth has only the lumbo-sacral angle to interrupt the spine's straight course. It is an extremely flexible spine because not only are the intervebral discs very large, the bodies themselves are still largely soft embryonic cartilage. Early in infancy traces of lordosis may be seen, both in the cervical and lumbar spine, and at three the dorsal region may acquire a beginning kyphosis. Tracings of the spines of living children made yearly by Schulthess show interestingly the development of these curves. Ossification in the spine is slow; though it begins early (the seventh week) the vertebræ keep on growing and adding epiphyses till the twenty-second year; and the last ones finally unite ten years later. The old man's spine is the reverse of the infantile; it is bowed, its movements restricted, the intervertebral discs are thin and wasted, and the bones light, thin, hard and brittle.

Fig. 42.—Infant's spine.

## PATHOLOGICAL ANATOMY.

**Pathological Anatomy.**—The study of pathological material has been confined to the severe forms; their dry bones have been carefully studied, the ligaments, muscles, and the internal organs have been studied by only a few; congenital curvatures associated with spina bifida and rhachischisis have been described, and recently some

cases of numerical variations of the spine. To Schulthess we owe much for compiling this material.

Museum specimens never show changes indicative of bone disease; on the contrary the modifications of form and structure suggest the prolonged effect of pressure and strain on growing bones. The spine curves to one side in some part of its length, or it curves to one side in one part and to the opposite side above or below, or both above and below; there is a deviation of vertebræ away from the median plane. Seen in front this is greater than behind, that is the column of bodies deviates more than the arches. In severe curves the sacrum and even the coccyx may deviate. The thorax and pelvis are often distorted. The vertebræ in the summit of the curve are rotated; they turn their bodies to the convex side of the curve. Though imperfectly understood it seems that the greatest amount of overhang or of flattening occur in those spines which exhibit the most rotation.

FIG. 43.—Diagram of the wedge and the lozenge vertebral bodies, the dotted outline is the normal.

Individual vertebræ show changes in their bodies, arches, processes and in the relations these bear to each other.

**Vertebral Bodies.**—The bodies in the apex of a curve, from two to five in number, are lower on the side of the concavity than on the convexity of the curve. They are wedge shaped and are styled wedge- or apex- or rotation-vertebræ, for they are rotated the most. They are widened out on one side by an outgrowth of their superior and inferior surfaces; and it is always on the concave side as if they were wax and their diminished height had been produced by melting and broadening them by pressure. Either one or both surfaces may be pared down, and the intervertebral discs are similarly distorted and bulge out on the concave side more than the bones do, concealing the bony outgrowth.

The bodies of the vertebræ immediately above and below them as far as the end of the curve, exhibit a very different distortion of structure; they are called oblique, torsion, or lozenge-shaped vertebræ.

The top and bottom surfaces are in parallel planes, but they are slightly displaced laterally on each other so that if viewed from the front the outline of the body is no longer rectangular but lozenge shaped; and the tops and bottoms have twisted upon each other, torsion-vertebræ.

As each of these vertebral bodies is both lozenge shaped and twisted in the same direction, they build up together in the column a curve of which the wedge-vertebræ form the apex, and one can readily see that both the lateral deviation and rotation are due to the asymmetrical shapes of these bones, a crooked column of crooked bones; and that the displacements of a vertebra upon its neighbor, due to the flexibility of the intervertebral discs, and movements of the joints, play no part in its formation; hence these are structural or fixed curvatures. The obliquity and torsion of the lozenge vertebræ is in the reverse direction above the apex and so causes a gradual approach to the normal direction of the spinal column above. The twist of these oblique vertebræ varies in different parts of the column and is greatest where two curves meet and least near the apex; torsion is often indicated by little oblique ridges on the front and sides of the vertebral body.

**The spinal foramen** undergoes a change of outline; in the dorsal spine it loses its roundness and is ovoid, with the point on the side of the concavity; in the lumbar the triangular shape is altered by rounding off the angle on the side of the concavity.

**The Arches.**—The arches too are distorted; the pedicles deviate both from their normal backward direction and from their normal degree of inclination, and their changes affect the rest of the arch and all the processes.

*The Pedicles.*—Excepting one or two vertebræ in the summit of the curve all the pedicles in the curve are distorted. Viewed from the side the pedicle of a wedge-vertebra is on the convex side directed more upward and on the concave side more directly backward than normal; seen from on top the convex pedicle has a backward, the concave, a backward-and-outward direction. In the oblique vertebra there is less difference between the right and left pedicles, but they are more nearly level below, and more steeply inclined above the summit of the curve. The length, breadth, and height of a

pedicle may also be changed from the normal; the concave pedicle of a wedge-vertebra is always broadened to correspond with the one-sided widening of the tops and bottoms of the body; its vertical height is less in the dorsal, and greater in the lumbar region; dorsal pedicles are long on the concave and short on the convex side, hence the paradox "both the body and the spinous process are turned toward the convexity," only true of dorsal vertebræ.

*The articular processes* are altered because of the displacement produced by the abnormal pedicles and from changes in their articular facets due altered statics and growth. On the concave side they are crowded together, the facets are enlarged, deepened and broadened, and the cartilage thickened; on the convex the facets are smaller than normal and closer to the tip of the process; one infers that the joints on the side of the concavity were more used and bore greater weight; they are also the oftenest ankylosed.

*The transverse processes* tend to remain more truly horizontal than the rest of the spine; in the dorsal region their rib attachments restrict and modify this, but in lumbar spines, with severe deformity, where this part of the spine sometimes inclines almost horizontally the distortion of the transverse processes is extreme and they are directed up and down with reference to the long spinal axis, though in reality they are parallel to the horizon.

*The laminæ* are not distorted to any extent.

*The spinous processes* turn as already noted to the side of the convexity in the dorsal spine. There they also are depressed so that they overlie and touch each other like shingles on a ridge which slope, as do also the laminæ. In consequence of the difference in elevation of the two pedicles and their different lengths the spinous process, which is the real point of union of the two halves of the arch, must twist. In the lumbar spine the angle which the process makes with the laminæ on the two sides is not equal, being smaller on the convex than on the concave side, as if a feeble attempt were made by nature to have the paradox hold good for the lumbar as well as the dorsal spine.

Probably muscle pull has much to do with the distortion of the transverse and spinous processes, but this is imperfectly understood.

## THORAX AND PELVIS.

**Thorax.**—So far conditions in the vertebræ only have been considered; the thorax and pelvis are so intimately attached that they are regarded as a part of the spine itself; they are frequently deformed in lateral curvature.

*Rib Joints.*—The joints between the heads of the ribs and the vertebræ are of two kinds; those between the head of the rib and the side of the body and those between the side of the rib and the transverse process. Both are, in severe deformity, displaced forward on the concave side and back on the convex side of the vertebral body; they are faintly indicated on the concave side, but deeply sunken on the side of convexity, and the ligaments are lax.

*Rotation of Thorax.*—In lumbar scoliosis the only change in the thorax would be a slight rotation of the whole thorax. In dorsal scoliosis the whole thorax is usually displaced laterally on the pelvis and its structure distorted. It has to maintain more nearly a normal position than does the spine. Its diagonal diameter from behind on the convex to in front on the concave side is lengthened and the other diagonal shortened, because of a sharper angle of the ribs on the side of convexity, and a flattened angle of the corresponding rib opposite; in front the ribs and their cartilages run with little curve to the sternum on the convex side, but are often on the side of their concavity bent to a sharp angle near the joining place of the rib and cartilage. These rows of prominent rib angles make a hump, the so-called rippenbuckel, rib-hump of the Germans, who refer usually to the posterior rib-hump. The ribs are more separated and more steeply inclined on the convex, more crowded and more nearly horizontal on the concave side. In some complicated curvatures as many as three curves with rib-humps may be seen. The sternum moves but little from its normal site; it may be displaced laterally or the tip may turn to either side, or it may rotate on its long axis, tipping the side toward the concavity forward under the skin.

**Shoulder-girdle.**—The shoulder-girdle shares in the changes in the thoracic wall as its position depends on the three things, the deformity of the thorax, the weight of the arm, and muscle-pull. A rib-

hump forces the scapula away from the spine and, if high in the thorax, causes it to rise; but the scapula may lie sagittally instead of frontally, or sometimes it may be forced back to overlie the spines. The clavicle is occasionally more curved on one side than the other.

**The Pelvis.**—The sacrum and pelvis are frequently distorted; in low lumbar curves the sacro-lumbar junction is often the apex of curvature; therefore one may see a decreased height of the first sacral on the side of the concavity with broadening on that side of the base of the sacrum, and a slight rotation of both the body and wings. Schulthess describes a sacral curve with apex at third and fourth sacral and deviation of the coccyx. Sacral distortions are slight and are detected by sighting along the front of the bone. In low curves with a sacral distortion the pelvic diagonals are unequal; in a low left lumbar curve the left posterior to right anterior is the longer.

## SOFT PARTS.

**The Muscles.**—Muscle in disuse atrophies and turns to fat; under increased demands it hypertrophies; when it rubs over the surface of a bone it forms tendon or fibrous tissue; permanent shortening occurs as an adaptation to an approximated position of its ends. All these changes are found in the severest scoliotics at autopsy, but the muscle changes of slight grades are unknown. The advanced changes described by Phelps and Schulthess seem altered beyond possibility of improvement.

**Internal Organs.**—The shortening of the trunk, the distortion and decreased capacity of the pleural and abdominal cavities affect both the growth and function of the organs.

*Lungs.*—Bachmann found from records of 182 autopsies on scoliotics that many have consumption, and many die of it, 28.3 percent of the severe cases, and 66 percent of the milder ones. The chest capacity is diminished most in the convex side when there is a marked rib-hump. Clinical corroboration of this fact is furnished by Mosse, who noted apex infiltration in 60.2 percent of scoliotic children; and by Kaminel and Zade, who found it in 73 percent of scoliotic women.

Adhesive pleurisy was found in 74.6 percent of Bachmann's autop-

sies; in 31 percent there was atelectasis of lungs, and in 23 percent pneumonia.

*Heart.*—The heart, usually displaced upward and crowded to the front, is often enlarged both by hypertrophy and dilation; the right heart was affected in 56 percent, the left in 17.5 percent, and both right and left in 25.9 percent. The aorta and the great veins are not much distorted but occasionally run an unusual course. The esophagus also varies but little from its normal course if the curve be a long one.

FIG. 44.—Specimen in Warren Museum showing displacement of the aorta in severe right dorsal kypho-scoliosis from its place on the spine to the left ribs.

*Abdominal Viscera.*—The diaphragm is pushed up high and, of course, follows the inclination of the thorax. The abdominal viscera are, in consequence of decreased space, crowded downward and forward and the small intestines occupy the cavity of the pelvis; the transverse colon may take an almost vertical course if there is much lateral displacement of the trunk to the right. The liver in right curvatures is crowded over to the left and the left lobe has a better chance to grow large. The right kidney in right curves is displaced up, the left down; the latter is oftener the seat of pathologic change: out of 180 observations, Bachmann found 14 cystic kidneys, 31 with granular atrophy, 18 with simple atrophy, and 6 hydronephroses.

The spleen may be displaced upward; perisplenitis, atrophy, and cyanotic induration have been observed. The stomach, owing to

the crowding downward and forward of the liver and with it of the duodenum, has a more vertical direction from the cardia to the pylorus.

## THE DEFORMITIES IN THE LIVING.

The deformities we may divide into five classes: The congenital, including those due to numerical variation of the spine whose deformity does not appear until puberty, or thereabouts; the functional, acquired through faulty habits of posture—the so-called school scoliosis; those due to diseases of the bones—rickets, osteomalacia, etc.; those due to thoracic diseases, such as empyema, enlargement of the heart, etc.; and the paralytic. It may turn out, as Böhm confidently predicts, that the second class should be included in the congenital, or, as he calls it, the idiopathic class in contradistinction to the other classes which are all symptomatic of deformities or diseases elsewhere.

Any part of the column may be affected, the curve may be capable of self-correction, of improvement, or it may be fixed so that we get no improvement. It is important, therefore, to know first of all about the cause of the lateral curvature, and secondly about the grade or capacity for correction. Anatomically there are cervico-dorsal, simple dorsal, dorso-lumbar, lumbar, complicated dorsal curves, and total curves.

The relative frequency of the different clinical forms is shown in the following table of Schulthess' from Joachimsthal's Handbuch der Orthopädischen Chirurgie:

| | Totals. | Principal Forms. | | With Compensatory Curves. | | Without Compensatory Curves. | |
|---|---|---|---|---|---|---|---|
| | | Left. | Right. | Left. | Right. | Left. | Right. |
| Total scoliosis, . . . | 175 | 156 | 19 | 6 | 1 | 150 | 18 |
| Cervico-dorsal scoliosis, | 42 | 26 | 16 | 17 | 7 | 9 | 9 |
| Dorsal scoliosis, . . | 217 | 112 | 105 | 10 | 32 | 102 | 73 |
| Lumbo-dorsal scoliosis, | 221 | 182 | 39 | 49 | 17 | 133 | 22 |
| Lumbar scoliosis, . . | 134 | 71 | 63 | 31 | 41 | 40 | 22 |
| Dorsal scoliosis, complicated, . . . . | 348 | 66 | 282 | 66 | 282 | — | — |
| | 1137 | 313 | 524 | 179 | 389 | 434 | 144 |

## TOTAL SCOLIOSIS.

We speak of a total scoliosis when a single long flat curve is discovered with the apex near the middle of the whole spine, the lower dorsal region. It implies both a curve of the spine, and one of the whole body from head to foot, with the pelvis displaced toward the side of convexity. These curves are slight and flexible, and it may be a simple malposture, or an early stage of development of either a left-lumbo-dorsal curve, a left-lumbar right-dorsal curve, or a simple commencing right or left dorsal curves. In fact they may be divided into true total curves and false. The attitude may be seen by the illustration, Fig. 45. It is much more common on the left side than on the right. The rotation in total scoliosis shows, when the patient bends forward, a prominence on the side of the concavity instead of the convexity of the spine, even when a back shows a very slight scarcely appreciable curve. This difference is distributed in the whole back, including the shoulders. Right-sided total scoliosis is rare, and Schulthess believes that it only exists as an early stage of other curvatures.


FIG. 45.—Total curve with plumb-line. (*Children's Hospital.*)

Total curvature is a little more frequent than simple lumbar curvature and constitutes about 15 percent of all cases of lateral curvature. The apex of the curve lies at about the ninth or tenth dorsal spine but it may be as high as the sixth or as low as the second lumbar. In the rare cases of right convex total scoliosis, Schulthess found the apex at the seventh dorsal. Hess

found that 70 percent of his cases of total scoliosis which were kept under observation for a long time remained unchanged in form. It is commonest from 8 to 10 years of age, and is more frequent in boys than in girls.

### LUMBAR SCOLIOSIS.

The row of spinous processes describes a short curve with its apex in the lumbar column, and the trunk is displaced sharply toward the side of the convexity, consequently, the re-entering angle at the waist is flattened on the convex side and much increased on the concave; hence parents speak of a child's hip "sticking out." There is marked rotation of the vertebræ, and in forward bending, the prominence in the loins is on the side of convexity, the flattening on the side of concavity. In most cases, the line of the spinous processes bends sharply from the vertical as it leaves the sacrum and soon curves toward the vertical again—a direction which it continues to maintain. In other cases the sacrum itself is not vertical but leans to the side of the curvature, and in another class of cases the upper part of the column gradually approaches or intersects the vertical erected at the fold of the nates.

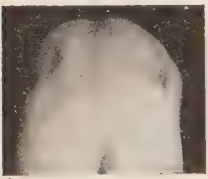

FIG. 46.—Total scoliotic stooping to show rotation to the right or side of concavity. (*Children's Hospital.*)

Antero-posterior curves of the spine may be present; the patient may have a round back or a flat back; marked lordosis is sometimes seen in cases of rhachitic origin. The lumbar curve is frequently an accompaniment of right dorsal curvature. As a rule these curves occur in older children. Schulthess found the age of the youngest to be 7 years, the oldest 28 years, and the average age, $14\frac{1}{2}$ years; the greatest number of cases occurred between the ages of 12 and 15 years.

### LUMBO-DORSAL SCOLIOSIS.

This form represents a fairly large proportion of all cases. The clinical picture often varies but little from the lumbar or from the dorsal cases where the curve has reached advanced proportions.

We notice first a change in the waist line, an accentuation of the re-entering angle on the side of the concavity and often a lateral overhanging of the ribs and trunk on the side of the convexity; but the short sharp curve at the top of the sacrum, which is so common in the lumbar form of scoliosis, is wanting. The apex is around the tenth dorsal, and the shoulder on the side of the concavity is often lower. Rotation is present and is noticeable on bending forward at the level of the apex of the curve, the back being prominent on the side of convexity and flattened on the side of concavity. Schulthess has seen reversed rotation but it is very rare. The shoulder on the side of concavity is displaced backward, that is, the rotation is often in an opposite direction from what it is in the lower part of the thorax.

FIG. 47.—Left lumbo-dorsal, a long flat, curve with rotation on side of convexity (left lower ribs). (*Children's Hospital.*)

Etiologically these simple lumbo-dorsal curves divide into three classes: Slight curves, usually due to functional scoliosis, and the severer forms due to paralysis or rickets. Rhachitic cases usually have marked lordosis, while paralytic backs are bowed backward. The latter are curves of long radius, and in the lighter forms, radiographs of the spine look quite straight. The most deforming type is left lumbo-dorsal kypho-scoliosis from rickets.

## DORSAL SCOLIOSIS.

Simple dorsal scoliosis, according to Schulthess, occurs in 19 per-cent of his 1140 cases. The deviation laterally is seen in the middle or lower dorsal column without any appreciable curves elsewhere, and without inequalities on forward bending which would lead us to suspect a secondary lumbar curve. The apex of the curvature, usually between the sixth and eighth, is associated with a certain amount of kyphosis, with the phenomena of rotation at the seat of the curve shown by prominent ribs on the convex side and flattened ones on the concave. The shoulders, however, may be twisted in the reverse direction so that the shoulder on the side of concavity is back of the other. Lateral displacement of the trunk may be very slight or wanting. The curve is sharp and the parents notice it. In many cases forward bending does not accentuate rotation of the ribs, but seems to make more marked the lateral deviation of the spines at the apex of the curve. This occurs only in cases of slight and moderate curvatures; in the severe forms the deformity from rotation of the vertebræ is prominent, and these cases are of rhachitic origin, according to Schulthess and Spitzy, and begin early in childhood.

FIG. 48.—Left dorsal kypho-scoliosis with shortened trunk. (*Children's Hospital.*)

Dorsal kypho-scolioses often suggest Pott's disease and may be mistaken for complicated curves on account of the length of the dorsal curve and the shortening of the trunk. Schulthess also calls attention to the fact that some right-dorsal-left-lumbar curvatures, in the course of years, become single dorsal curves with marked trunk shortening. The reverse is also true, a simple dorsal curvature in the course of years may develop a secondary lumbar curve; but this does not always occur.

There is a definite specific character to the simple dorsal curve, whether right or left.

## CERVICO-DORSAL SCOLIOSIS.

Cervico-dorsal curves present a typical clinical picture they are sharp, short curves, usually convex to the left with the apex in the neighborhood of the third or fourth dorsal spine, with strong deviations of the trunk and considerable overhang which is quite char-

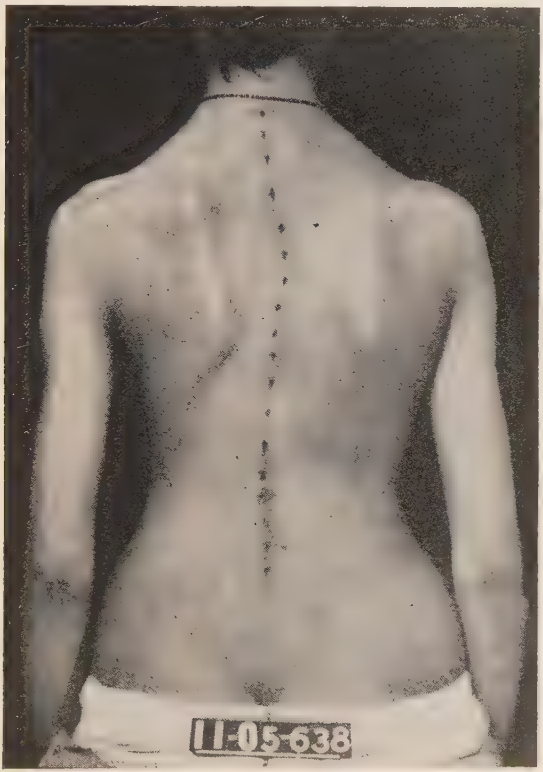


FIG. 49.—Right dorsal scoliosis with amesial pelvis. (*Children's Hospital.*)

acteristic of this form of scoliosis; the head is always thrust forward and usually leans a little toward the concave side; the sides of the neck are markedly altered and there is a prominence sideways and backward on the convex side and the shoulder droops on the concave

side; the arm hangs from a shoulder which is pushed forward by the convexity and the whole trunk seems displaced toward the concave side, which may be demonstrated by a plumb line from the cleft of the buttocks which shows the head displaced almost entirely on the concave side. Even in slightly developed curvatures, the characteristic high forward position of the shoulder-blade is always seen.


FIG. 50.—Right-dorsal-left-lumbo-dorsal curvature with marked rotation. (*Children's Hospital.*)

Schulthess regards these cases as rhachitic. A sharply angular rib-hump is usually noticed, which pushes the scapula out of place upward and forward so that the plane of the scapula is more nearly sagittal than frontal and the angle of the scapula is often very prominent under the skin; on the concave side the reverse takes place—the scapula is lowered and swings inward so far that it may touch or overlap the row of spinous processes. The extreme lateral deviation seen in these cases may be accounted for by the endeavor to balance and keep the head straight with reference to the horizon.

### COMPLICATED DORSAL SCOLIOSIS.

Patients with complicated dorsal scoliosis present two or more lateral deviations simultaneously. This was formerly regarded as the only typical form of scoliosis, because the physician was not consulted until the curvature had become a very severe deformity. From a mathematical standpoint it would seem as if dorsal curvatures should be compensated for by a

curve in the reverse direction above and below; but this is not always the case. Not only does the deviation laterally of the line of spinous processes show the presence of one or several complicated curves, but the appearances from rotation which are seen on forward bending give a strong hint as to the true position of the column. This hint is especially useful in establishing the presence of complicated curves of slight degree; and any flattening of the back on one side and prominence on the other side which is reversed in the upper and lower portions of the back is to be heeded as if one had to do with a scoliosis with convexities toward the prominences.

FIG. 51.
Lateral curvature with a hollow round back. (*Children's Hospital.*)

The difference is usually appreciable in the position of the shoulder-blades—that on the convex side wanders back toward the vertebral column and appears abnormally prominent; the opposite shoulder-blade on its flattened thorax is displaced far outward and forward and tips so that its lower angle is prominent, and by this means compensates for a certain amount of flattening of the chest.

When the dorsal deformity is high, the shoulder-blade is pushed up on the convex side as in cervico-dorsal cases; the trunk may center properly over the sacrum or be displaced laterally. Apparent symmetry is often obtained owing to the reverse direction of the curves. Besides there is deviation in an anterior-posterior direction for few complicated dorsal curves have a flat back. The back may give the impression of a total lordosis and the row of spinous processes appear as a deep furrow between the shoulder-blades, so that it is difficult to make out the lateral curves, but in the forward bending position the rib-hump is prominent, not in the erect position. There is always marked rotation in the lumbar column in an opposite direction to that seen in the dorsal, and often there is a sharply localized bend of the column in the neighborhood of the lumbo dorsal junction. Localized lordotic

bending may be seen in the dorsal segment combined with the deformity of rotation and considerable lateral deviation of the trunk. In another set of complicated curvatures marked kyphosis is present from the very beginning and there is relatively little development of side deviation.

These different types of deformity are combined in most varying pictures. There are all sorts, varying from a scarcely noticeable suggestion of a double curve to the severe structural deformities with lateral displacement, trunk shortening, inclination of the lumbar column to the horizontal, marked rotation, kyphosis with overhanging rib-hump and shortening of the trunk.

The kypho-scoliotic cases always present a deformity of great severity, as the sharp prominence of the rib-hump, the shortening of the trunk with the descent of the ribs within the crests of the ilia, all indicate very severe grades of deformity.

This form is, however, very uncommon among school children.

**The Causes of Lateral Curvature.**—The many causes of scoliosis fall into four groups; the congenital, the osteogenous, the mechanical, and the functional.

*Congenital Scoliosis.*—Here (see Chapter II, page 16), there are congenital deformities due to numerical variations in the spine, and malformations like spina bifida which give rise to lateral curvature. These congenital scolioses unrecognised for many years, are now subdivided into the deformities which are appreciable at birth and those which develop later. More study with the radiograph is essential in these cases.

Schulthess describes several cases arising from spina bifida. In one there was a rudimentary formation of the third lumbar vertebra associated with spina bifida, producing a left lumbo-dorsal curve; she had also an unequal length of legs and she kept one knee bent, but by straightening both knees the curve could be changed into a right lumbo-dorsal curve. The second case, a 13-year old child, had a sharp, right-convex dorso-lumbar curve due to spina bifida. Another child with congenital elevation of both shoulder-blades had spina bifida occulta in the cervico-dorsal region and a cervico-dorsal curve. High dorso-cerv-

ical scoliosis has been described by Garré with cervical ribs and may be present whether the extra ribs be on one side or on both.

Schulthess describes a bilateral case. Drehmann, of Breslau, has described congenital defects of the bodies of the vertebræ belonging with cervical ribs and has demonstrated the existence of these malformations by the X-ray; this may explain why scoliosis is found with symmetrical cervical ribs. A diagnosis of congenital scoliosis may depend upon a satisfactory radiographical demonstration of the deformity.

*Osteogenous.*—In rickets one has to depend upon the history for the diagnosis; unless it left its mark behind it as a bow-leg, knock-knee, or pigeon breast. As a rule, cases with marked kyphosis and lordosis arouse a suspicion of rickets. Schulthess finds that the ordinary antero-posterior curve of acute rickets may be associated with rotation which may be seen by having the child lean forward or by a cross tracing taken in that position. Early rhachitic curvature always kyphotic, may become kypho-scoliotic, or it may commence as such; later in life it remains kyphotic. A lumbar kyphosis is regarded by Schulthess as particularly suggestive of rickets, with it the back is flat with a sharp angle at the promontory. In little children with florid rickets Schulthess found a few lumbo-dorsal and lumbar curves with marked kyphosis becoming double curvatures with marked thoracic deformity, or with a high dorsal curve or a cervico-dorsal curve. The younger rickets begins, the more likely is the curve to be low in the column. A double curve has, however, been seen in a nursing baby. Schulthess and Spitzy, in infants found both thoracic distortion and an obliquity of the skull, which is oblique in the opposite direction to the thorax, but this deformity may, in some instances, have

FIG. 52.—Lateral curvature from hip disease with deformity. (*Children's Hospital.*)

begun before the closure of the sutures and have been due to the force of gravity only (see chapter VII, page 85). Rhachitic deformities of the legs which fail to grow straight, such as bow-leg, knock-knee, and coxa vara, may produce pelvic tilting, especially if one leg only is deformed. Spitzy holds that in many cases of slight lumbar kyphosis in acute rickets a slight lateral curve is present; but the diagnosis of rhachitic scoliosis in older people must necessarily be very difficult if the signs of pre-existing rickets have been outgrown.

FIG. 53.—Scoliosis from infantile paralysis, drawing from photograph.

*Mechanical Scoliosis.*—Lateral curvature is often the result of a tilted position of the pelvis arising from some cause outside of the spine and pelvis, a one-sided bow-leg, knock-knee or coxa vara, in fact any sort of short leg may cause it; shortening from fracture or hip disease, tumor albus, ankle-joint disease, even flat-foot may produce a mechanical scoliosis. I have seen it from lengthening of the limb as the result of a septic compound fracture of the tibia, with suppuration for a year near the lower epiphysis of the tibia which apparently stimulated it to overgrowth. Ankylosis with flexion of the hip, knee, or ankle, or congenital dislocation of the hip may produce it. In the upper extremity these mechanical causes are less effective, but it may arise from disease of the shoulder-joint with ankylosis.

Another form of mechanical scoliosis comes from empyema. Scoliosis with thoracic deformity as a result of suppurative pleuritis was described by Delpech in 1827. In empyema, after the pus is evacuated or when absorption takes place, the thoracic space on that side is lessened, for cicatrical tissue forms whose slow contraction diminishes the pleural capacity both by fastening the diaphragm higher on the thoracic wall and by narrowing the intercostal spaces. In most cases there is a lateral bowing of the lower part of the dorsal spine

or a double curve with the dorsal convexity toward the sound side. The deformity presents a striking appearance, as the affected half of the chest seems much smaller than the healthy side. The worst deformity comes in those cases where nature, unaided, cures the empy-

FIG. 54.—Left empyema—Scoliosis after drainage and resection of ribs. (*R. W. Lovett.*)

ema by absorption, although lateral curvature may arise frequently after surgical treatment, resection of a rib, and drainage. A strong, well-developed appearance of the healthy side of the thorax is always suggestive. The usual vertebral rotation toward the convexity of

the curve is seen in these cases. A unique specimen in the Warren Museum shows rotation of the bodies of the vertebræ toward the concavity of the curve in the contracted chest of cured empyema. Cases with long continued drainage from small sinuses are especially prone to deformity. That non-purulent effusions in the pleural cavity may end in lateral curvature seems probable.

Another form of mechanical scoliosis is seen in paralytics. But infantile paralysis of the back often produces no permanent deformity, but a malposture, which is unsightly but quite flexible, and disappears on lying down. When a bone curvature is present, it is the result of a weak leg, a paralyzed arm, or paralysis of one side only of the back. The curves are always slight or moderate,—they are long bowings, the arcs of a long radius. For diagnosis they usually offer no difficulty.

Ischias scoliotica is the name of a transitory malposition due to myalgia or neuralgia, lumbago, or sciatica.

*Functional Scoliosis.*—The diagnosis of functional scoliosis is made by excluding other causes.

## CHAPTER VIII.

# LATERAL CURVATURES (CONTINUED).

## METHOD OF EXAMINING AND RECORDING.

**History.**—The deformities may be hard to understand and appreciate correctly, and, as they undergo many changes in the progress of the disease, it is essential to keep a careful and accurate record of the deformity each time it is seen.

In the beginning the history is to be studied with care and a careful physical examination is made to discover the causative factors, rickets, osteomalacia, empyema, paralysis, etc;. if any are discovered, the treatment must include the underlying condition. The eyes and ears should be tested, for inequality in the position of the head from faulty vision or hearing may be a cause of lateral curvature.

**Physical examination** should begin with a view of the bare back in the standing attitude.

*The Back in Standing Attitude.*—The child's entire trunk and in older girls the entire back should be seen, so the patient wears a short dressing sack, which is made to open in the back and the clothing is fastened about the hips with a belt low enough for half the fold between the buttocks to be visible; the feet should be placed parallel, about 6 inches apart, and the patient stands with the knees straight. You observe from behind the position of the head, the outline of the sides of the neck and shoulders, the outlines of the waist and the inner borders of the arm, the surface of the different parts of the back and the prominence or flattening of each hip. The patient should maintain the position a few minutes until, under the effect of fatigue, she sags or slouches. Stooping of the neck and shoulders and sticking out the stomach should be noted. Also lateral deviation of the trunk from a plumb line held at crease between the buttocks; the eye then tries to follow the line of the

spinous processes, which may be facilitated by applying two fingers on either side of the seventh cervical and with firm pressure drawing them downward keeping the spinous processes between them; in a minute a red line appears where the pressure was made; or, each spine may be felt and marked separately with a skin pencil. Measurement of the greatest distance the spinous processes have deviated laterally is made by stretching a string tightly from the top of the internatal fold to the tip of the seventh cervical spine and measuring from this as a base line.

*The Back in Forward Bending.*—After recording his observations, the observer, seated behind the patient, directs her to bend forward, and sighting along the back, looks for rotation, that is a difference in the prominence of the soft parts on either side of the spine in the lumbar and dorsal regions. Then the patient stands erect while the observer looks down upon the back from above to see if the shoulders lie squarely in the transverse plane of the body or have rotated one in front and the other back of the plane.

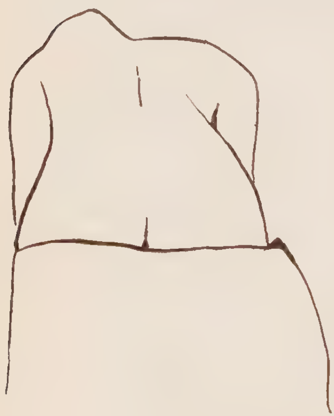

FIG. 55.—Patient stooping forward to show rotation in the dorsal region in a left dorsal curve.

*Tracings and Photographs.*—Many devices have been employed to make a tracing or record of the amount of lateral deviation in different parts of the spine and of the amount of rotation, so that the condition may be compared with it.

One of the simplest was devised by Freiberg, of Cincinnati; it consists in holding up against the marked back a long narrow strip of glass longitudinally bisected by a straight line which is placed so that it connects the fold between the nates with the seventh cervical spine; with a pencil for marking glass, dots are then made on the glass to correspond with those over the spines; from the glass plate, a tracing is then made on paper, or the distance of each dot from

the line is measured and transferred to coordinate paper and a curve of reduced proportions preserved in the record. A good photograph of the back, properly lighted, is a very satisfactory record, and with a little care may easily be obtained in the office by the physician. A thread screen, a square frame strung with strings an inch apart crossing at right angles, may be interposed close to the patient's back while the photograph is taken, so that measurements of the dots over each spine may be made on the photograph in fractions of an inch. This method was employed 15 years ago at the Children's Hospital, but was abandoned. It is now in vogue in many European clinics.

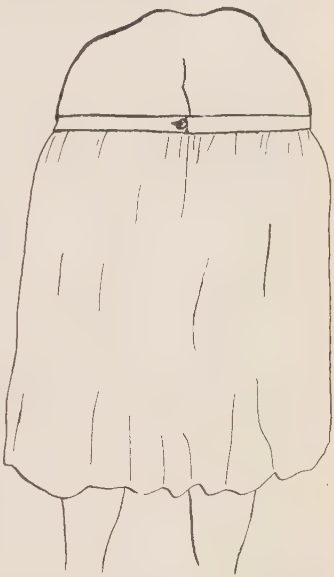

FIG. 56.—Patient with right dorsal left lumbo-dorsal curve stooping far down and forward to show rotation, a prominence of the lumbar muscles and of ribs on the right.

Many mechanical devices have been constructed to make record tracings. Those of Zander and Schulthess are accurate but expensive.

*Flexibility.*—The examination should include a test of the flexibility of the spine.

Forward and backward bending is easily observed with the patient standing and bending; the hips should be steadied to get out the full range of spinal movement. Then the patient is asked to bend as far as she can to the right and left. When twisting to right and left is tested, the surgeon should again hold the pelvis to prevent a general twist of the whole body.

The patient then lies prone in order to discover if the rotation of the ribs disappears; if it remains the curve is a fixed one. The patient, standing, should then exert her powers to correct her deformity in order to see which of the three clinical grades she belongs in;

that is, whether she can correct the curve herself, whether she can only improve it, or whether she cannot do even that.

In testing the range of the different spinal movements, it is necessary for the student to know what their range is normally in the different regions of the spine.

FIG. 57.—Left lumbar scoliosis. The lines are drawn vertically to the fold between nates in the upright position and in right and left landing, and they show that she bends to the left easily, but is very stiff bending to the right. (*Lovett.*)

MOVEMENTS OF THE SPINE.

Movements of the spine are flexion or bending forward, hyperextension or bending backward, lateral flexion or side bending, and rotation or twisting. The two last always come together, as Lovett and Dwight have shown, and this is equally true of any rod which, having already a curve in one plane, is bent in another. It is also true that one movement predominates and the other is slight.

Flexion is the most evenly distributed of the movements, but the thoracic spine bends least; the bent back is curved like the arc of a large circle. Hyperextension takes place largely in the lumbar and two lowest dorsal vertebræ, in the neck the head makes it hard to estimate, but there is considerable motion while the dorsal spine only straightens. Side bending in the position of lying on the face or back is a distributed motion but is greatest in the dorsal and upper lumbar region; if the child

stands leaning forward, side bend occurs only in the middle and upper dorsal and the cervical region, the lower dorsal and lumbar remain rigid and straight; the erect spine bends sideways chiefly in the lower dorsal, the upper lumbar and the neck while the upper dorsal spine remains stiff; the hyperextended spine bends to the side very little and only at the lumbo-dorsal junction. Rotation, freest in the upright attitude, is restricted to the cervical and upper dorsal spine in leaning forward and to the lumbo-dorsal junction in hyperextension.

The cervical spine, excluding the atlas, flexes enough to lose its lordosis, and hyperextends considerably; side bending and twisting are permitted moderately throughout, so their sum is considerable.

The dorsal spine flexes but little and hyperextends hardly enough to straighten, except that the last two vertebræ move more; lateral bending is evenly distributed and of fair amount, but the lower spine may be locked against it by bending forward and all but the lowest part by bending backward; rotation is greatest in the dorsal region, about 55° to either side; it takes place most at the top, becoming progressively less lower.

The lumbar spine flexes freely but fails to lose its lordosis completely, it hyperextends more than any other region; side bending is more than in the dorsal region and is associated with rotation of the bodies to the concavity; flexing prevents and hyperextension diminishes side bending; very little rotation takes place in the lumbar spine and only in the upright position, and may be increased by traction.

## TREATMENT.

### MALPOSTURES AND EARLY SLIGHT DEFORMITIES.

Slight amounts of spinal deviation are best recognized by holding a string as a plumb line with the lower end falling on the cleft of the buttocks. In the erect position of a normal spine, every spinous process should lie under this plumb line. Slight degrees of curvature detected in this way should then be examined for rotation by bending forward and, if absent, they are classed as postural cases.

The most common type of malposture is the total left curve, but

it is always accompanied by a slight rotation with a prominence of the back in the concavity instead of convexity of the curve the reverse of the usual rotation; the spine has a gradual sweep to the left, the left shoulder is high, and the right, the depressed shoulder, lies on a plane posterior to its fellow. Lumbo-dorsal and dorsal curves are also found in the early cases of slight deformity without rotation. As there is no rotation, it is assumed that there is no bony deformity and the condition is a faulty attitude, not a bony deformity. The prognosis for complete recovery is good.

The object of treatment is to substitute correct standing for faulty. It is important first to restore to the column its former flexibility, often very deficient, and then to strengthen and develop the muscles by gymnastic exercises which amount to the setting up drill of the soldier. The surgeon should instruct some good teacher of gymnastics how to carry the exercises out. If children are in obviously poor muscular condition or overworked at school, they should give up school for a year and be placed under the most favorable conditions obtainable; errors of vision should be corrected; a short leg, if present, should be compensated for; the weight of the clothing should no longer be carried on the tips of the shoulders where it usually is; exercises should not be pushed beyond the limit of fatigue, but they should be performed daily, for three-quarters of an hour or an hour, for several months, after which gymnastics should be done night and morning at home, for at least a year. Half-way measures fail. Exercises under the supervision of careless parents are most unsatisfactory.

The following exercises from Lovett's recent book on "Lateral Curvature and Round Shoulders," are given with his permission. They are not all intended for postural cases; as the careful reader will observe, the muscles employed in each exercise are defined, as well as the objects which may be realized in the particular sort of deformity present.

Gymnastic exercises may be given in apparatus, or without it; the apparatus of Zander, and the apparatus of Schulthess and its modifications are in use in many places in Europe, but as such apparatus is seldom found in this country we pass to the exercises with-

out apparatus. Gymnastic treatment indeed has its limitations, and the chief one is that force is not used locally, but that forces and movements are distributed over the greater part of the back and trunk.

"*Fixation of Pelvis.*—It is essential that the pelvis should be fixed during such exercises, as otherwise the pelvis is displaced and the movement becomes a general and not a local one. A simple wooden apparatus may be constructed which holds the pelvis and does away with the necessity of holding the hips of the patient between the knees which must otherwise be done. This saves labor on the part of the person giving the exercises, and permits a closer supervision of the back than is possible when part of the attention must be fixed on holding the patient firmly.

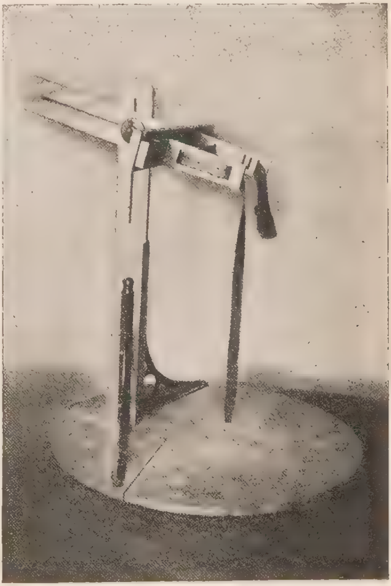

FIG. 58.—Apparatus for fixing the pelvis during gymnastic exercises. (*R. W. Lovett.*)

"An apparatus, which was suggested by that of Bade consists of a wooden clamp made by two flat boards sliding at right angles to a horizontal board (on which they slide) to hold the sides of a pelvis of any width. The whole apparatus moves up and down on an upright fastened to a large round floor platform and may be inclined at any angle to the horizontal plane. The patient is secured in place by sliding in and fastening the lateral clamps at the sides of the pelvis, and by securing the front of the pelvis by a broad leather strap passing from one arm to the other. The floor platform is so large that the apparatus cannot upset.

"*General Routine and Precautions.*—It is desirable that the back should be exposed during the exercises in order to note the effect of each one. For this purpose the patient should wear during exercises a loose cotton dressing jacket, fastened around the neck and opening in the back. This protects the front of the body but permits inspection of the spine.

"Such exercises should be simple and corrective in the strict sense; that is to say, an exercise which is of use should be seen to straighten the spine visibly. Complicated exercises are dangerous and unsurgical. Work to obtain results must be given by a competent gymnast for a period of from one to three hours a day, according to the vigor of the patient, and must be continued under personal supervision for a period of some weeks or months to obtain satisfactory results. After this, exercises at home can be substituted for part of the personal work.

"As a preliminary of gymnastic work the heart of the patient should have been, of course, examined, and the weight should be taken each week. Persistent loss of weight is an indication for moderating or discontinuing temporarily the exercises, providing that the patient is not being overworked at school, in which case the school conditions should first be remedied. During menstruation gymnastic exercises should be suspended. Persistent fatigue, anemia, loss of appetite, nervousness and frequent or profuse menstruation should cause a careful investigation of the patient's environment, as they may arise from excess of gymnastic work.

"The following list of gymnastic exercises, selected from a large number, may be regarded as representative of the kind of gymnastics likely to be of use within the limits mentioned above. They will first be described individually and analyzed, and their application to different conditions will be indicated.

"The selection of exercises must depend on the requirements of each case, and so far as possible the especial value of each exercise has been indicated. Simple developmental exercises have not been included here, as a description of them can be found in books on gymnastics.

"In the explanations to be given in connection with each exercise

the general mechanical features will be discussed, but it must be remembered that conditions observed in the normal do not necessarily hold true in the deformed spine of scoliosis, although they form the best basis for analysis. The more nearly a spine approaches the normal the more likely is such analysis to be correct.

## "SYMMETRIC EXERCISES.

### "EXERCISES IN THE STANDING POSITION.

"In all exercises given in this position *the pelvis should be fixed* unless otherwise stated. It must be remembered that exercises in this position call into play in varying relations all muscles concerned in maintaining the upright position and, therefore, cannot be as highly specialized as can exercises given in the lying position. It must also be remembered that the superincumbent weight rests on the laterally curved spine, and that the curves are, therefore, not in as favorable a condition in such exercises as in the lying position. On the other hand they are useful because any improvement of scoliosis must be interpreted as meaning improvement in the upright position, and all muscles concerned in that are therefore of importance.

"**Fundamental Standing Position.**—The patient stands with the knees extended, the hands on the hips, the back straight, the head erect, and the scapulæ brought close to each other. The patient should not exaggerate the lumbar curve, and should press down with both hands on the hips.

"I. *Shoulder Raising and Sinking.*—(1) From the fundamental standing position the patient stretches the whole spine upward. The surgeon holds his hand slightly above the patient's head and urges her to stretch until she can touch his hand with her head, keeping both heels on the ground. The position of the hand is made higher as necessary. (2) From the upward stretched position the patient relaxes to the fundamental standing position. In count (1) the patient breathes in and in count (2) breathes out.

"This is a general exercise calling upon the muscles which maintain the proper erect position, notably the spinal extensors. The elevation of the shoulders elevates and fixes the shoulder-girdle,

giving a fixed point for the pull of the inspiratory muscles, thus tending to increase chest capacity (and a general stretching of the spine is also made easier by the fixed shoulder-girdle). The exercise is applicable to any case of scoliosis, especially to postural curves, as a general mobilizing and corrective one.

"II. *Trunk Bending Forward with Shoulders Raised.*—(1) The shoulders are raised as in Exercise I, (2) The patient bends her trunk forward to the horizontal position, the spine being held straight and the shoulders raised, movement occurring only in the hip-joints. (3) The patient raises the trunk to the upright position

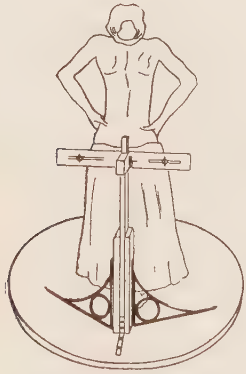

FIG. 59.—Exercise I. Shoulder-raising. (*Lovett.*)

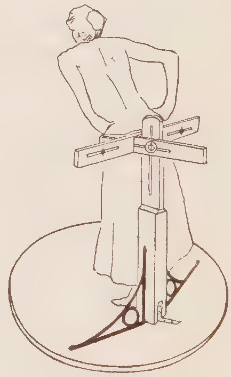

FIG. 60.—Exercise II. (*Lovett.*)

with the shoulders still raised and the spine straight. (4) The patient relaxes to the fundamental standing position.

"This combines the essentials of Exercise I with the weight of the trunk thrown on the extensor muscles of the back and on the glutei, which must be held contracted to maintain the forward bent position and which must contract to bring the trunk again into the upright position. It has the corrective effect of Exercise I, in addition to which it is a fairly strong extensor spinal exercise with the lumbar curve flattened. It is a general mobilizing and corrective exercise which may be safely used in cases with a tendency to exag-

geration of the lumbar curve. The patient inspires in (1), holds the breath during (2) and (3), and breathes out in count (4).

"The above exercises may be modified and made slightly heavier by having the patient place both hands behind the neck with the elbows square back as far as possible. This raises the center of gravity of the trunk and therefore increases the leverage against the muscles.

"III. *Trunk Circling.*—Position: Hands on the hips, the trunk flexed to the horizontal, the spine straight. From this position the patient describes a circle with the trunk about a vertical axis passing between the feet. The horizontal plane of the circle described is quite irregular, and the movement is divided into four counts. (1) From the position of forward bending the trunk passes to the right or left through side bending with flexion and rotation to extreme side bending. (2) From extreme side bending the circle is continued backward through side bending with its accompanying rotation to extreme hyperextension of the median plane. (3) The reverse of count (2). (4) The forward bent position is assumed. The face is directed forward during the entire exercise.

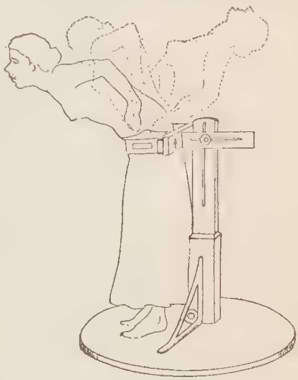

FIG. 61.—Exercise III. (*Lovett.*)

"This is a general mobilizing and strengthening exercise. When a marked lumbar curve is present the exercise is preferably made unilateral to the side that improves rather than increases the lumbar curve, *e.g.*, in a left lumbar curve, half circling to the left is preferable to the complete circle so far as any corrective aspect is concerned.

"IV. *Swimming.*—Position: The patient bends forward until the trunk is horizontal, the arms are held at the side, the elbows flexed, and the hands together against the chest. (1) The arms are extended upward beside the head. (2) The arms describe a half circle outward and are brought to the sides of the body. (3) The arms return to position.

"In this exercise the pelvis is flexed on the hip-joints, and the weight of the trunk is thrown forward. The extensor muscles of the spine and the glutei are called upon to maintain the position during the movements of the arms. All the muscles of the shoulder-girdle, especially those concerned in drawing the scapulæ together, take part in the movement. This is a general strengthening exercise, especially addressed to spinal extensors, and is also valuable in cases of flexible round shoulders.

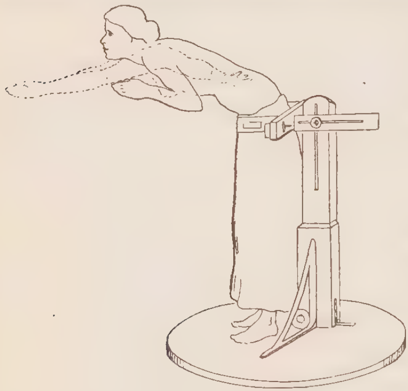

FIG. 62.—Exercise IV. (*Lovett.*)

"V. *Head Movements from the Fundamental Standing Position.*—The head and cervical spine, as far as possible, alone should participate in these exercises. (*A*, 1) Head flexion, (2) original position; (*B*, 1) head hyperextension, (2) original position; (*C*, 1) side bending of the head to the right or left, (2) original position; (*D*, 1) head twisting, right or left, (2) original position; (*E*) head circling with the face to the front, a combination of *A*, *B*, and *C* following one another.

"General mobilizing exercises for the cervical region. For corrective effect in a cervical curve they should be given only to the side that improves the curve.

"EXERCISES GIVEN IN THE HORIZONTAL POSITION.

"In this group of exercises one set of muscles may be more readily picked out for exercises than in the erect position. The spine when prone is less curved than in the upright position, and is slacker and more easily capable of side displacement. The fact that symmetric hyperextensions are so much used for their corrective effect is explained by their empirical value and by anatomic reasons.

"**Lying on the Face.**—VI. *Trunk Raising.*—Position: The patient lies face downward on a table with the spine straight, the hands on the hips, the scapulæ approximated to each other, the toes brought over the end of the table, and the legs secured to the table by a strap passing around the table and legs just above the ankles, or the legs may be held by the hands of an assistant. (I) The patient inspires and raises the trunk from the table, hyperextending the spine as far as possible, keeping the head back and the face up, with the elbows still held well back. (2) The patient breathes out and sinks to the original position.

"This is a movement of the spine from its normal position to extreme hyperextension in which the spinal motion occurs largely below the

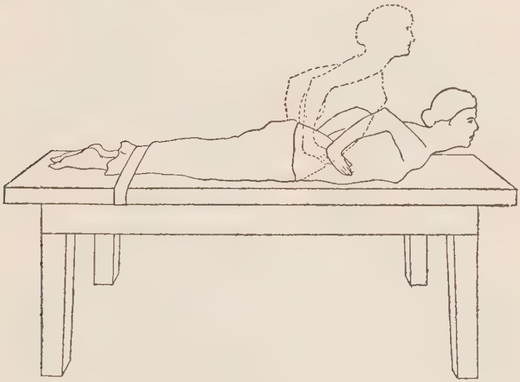

FIG. 63.—Exercise VI. Trunk raising. (*Lovett.*)

tenth dorsal vertebra, where hyperextension anatomically takes place. The weight of the trunk is raised by action of the back extensor muscles, which are pretty generally called into play. It is a general strengthening exercise for these muscles, but in cases with marked increase of the lumbar curve it must not be used to increase this, in such cases Exercise II being available. The latter is probably a weaker exercise, because in it the extensor muscles do not contract to their fullest extent. The exercise may be made harder by placing the hands behind the neck and squaring the elbows back, which raises the center of gravity.

"The above may be modified in the following manner: The patient clasps his hands behind his back above the level of the waist-line, with elbows flexed and hands close against the back, and, as he hyperextends his trunk, stretches his arms backward forcibly, extending the elbows, and keeping the hands clasped. By this modification the scapulæ and the shoulder-joints are carried back and the hyperextension done with an improved position of the shoulders. This is particularly suited to round shoulders.

"**Exercises Lying on the Face, the Trunk Projecting over the End of the Table.**—The legs rest on the table, the surgeon making the ankles secure by means of a strap or by holding them. The body above the hip-joints hangs over the table end, head downward. The hands are placed behind the neck with the elbows squared back.

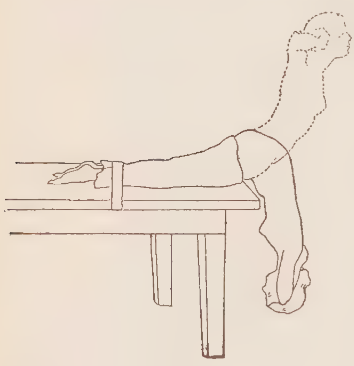

FIG. 64.—Exercise VII. Trunk-raising from head down position. (*Lovett.*)

"VII. *Trunk Raising from Head Downward Position.*—(1) The patient inspires, and raises the trunk as far as possible by hyperextending the hip-joints and the spine. (2) During expiration she sinks to the primary position. The spine should be kept in the mid-plane and the head not allowed to flex.

"This is a spinal extension movement mostly without superincumbent weight, beginning at forward flexion and ending in marked hyperextension, calling the extensor muscles into activity from a stretched to a completely contracted condition. It thus combines the range of motion in Exercise II with that of Exercise VI. It is a heavier exercise than either. From the start of the exercise till the active horizontal position is reached the spinal extensors and glutei are the muscles chiefly active, as the maintenance of balance does not require the contraction of other trunk muscles. The exercise may be made easier by placing the hands on the hips. It

is of use as a general strengthening exercise for the back muscles in any case where the patient is strong enough to take it.

"VIII. *Trunk Circling.*—The position is the same as in Exercise VII. The exercise is done in four counts, as described under Exercise II.

"This is a heavier exercise than II because the weight of the trunk is a factor entering into each component of the movement. For corrective effect it should be given only to the side that improves the lateral curve.

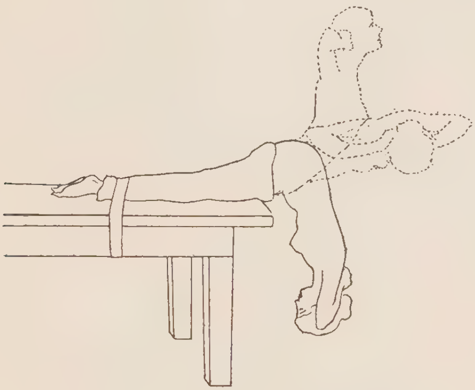

FIG. 65.—Exercise VIII. Trunk circling. (*Lovett.*)

Exercises lying on the back: the chief one of these is the familiar trunk-raising from the lying position. This is not an exercise for back muscles but for abdominal muscles, which are often weak, in cases where a correction of lordosis is demanded.

### "EXERCISES IN THE SUSPENDED POSITION.

"The patient stands erect, and the head is pulled vertically upward by means of a Sayre head-sling, which embraces the chin and occiput. Traction should be made by a compound pulley, and the patient or the surgeon may hold the rope. Suspension is mildest (1) when the feet are not made to leave the floor; next in grade comes (2) the position of tiptoe induced by the traction, and (3) a greater

pull is secured by lifting the whole body until the feet swing free. In this case the traction force equals the body-weight. The maximum traction can be secured (4) by strapping the thighs down to a seat on which the patient sits. An upward pull greater than the body-weight can now be exerted on the head.

"Head suspension is a passive stretching of the spine, corrective through its entire length, tending to improve both rotation and side deviation at the curves, but exercising still more force upon the more nearly normal parts of the spine because the latter are more

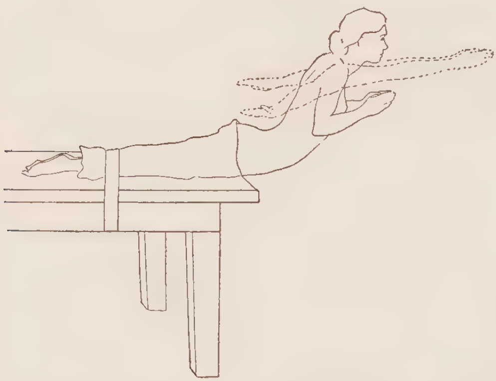

FIG. 66.—Swimming over end of table. (*Lovett.*)

movable. Suspension by the arms is less efficient, and does not affect the cervical vertebræ as does head suspension. Hanging is a generally useful and purely mobilizing procedure suitable to any case, slight or severe.

"If it is desired to make hanging exercises more locally corrective in the dorsal region the patient should hang by the hands from a bar, the hand on the convex side of the lateral curve grasping a loop on the bar which is at least two inches below it. By this means the concave side will be subjected to a greater stretching.

"MISCELLANEOUS SYMMETRIC EXERCISES.

"IX. *Weight Carrying on the Head.*—A bag filled loosely with sand, weighing from 3 to 15 pounds, is placed on top of the patient's

head, and she walks slowly to and fro with the arms preferably clasped behind the neck and the elbows squared back. The exercise may be made more difficult by having the patient walk on tiptoe. The attitude assumed should be as erect as possible and the weight as heavy as can be carried steadily.

"It is a matter of common information that the habitual carrying of baskets and loads upon the head induces an erect carriage and a straight spine. The presence of weight upon the head necessitates getting the spine as much as possible straight under the weight, as it is thus most economically carried, and this instinctive adjustment to superincumbent weight is depended on for its corrective effect. To carry a weight on the head with the spine not held in its best position by muscular effort would be undesirable. The exercise is suited to mild cases with noticeable bad carriage and poor balance.

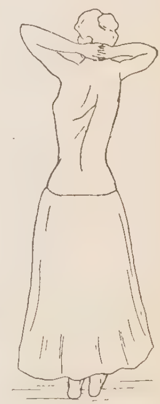

FIG. 67.—Trunk-twisting. (*Lovett.*)

"X. *Mirror Self-corrective Exercise.*—The patient, bared to the hips, faces a mirror in front of which hangs a plumb-line. The patient then stands in such a position that the plumb-line cuts the middle of the pelvis, and by a muscular effort brings the middle of the thorax and the vertical line of the face as nearly as possible under the plumb-line, bringing thus three important landmarks into the median line of the body, thus securing an improved position. This is held for a few seconds and then the relaxed position resumed. The exercise is repeated several times, the improved position being held longer each time.

"The exercise is a muscle training and is not in any way a mobilizing exercise, but enables the patient to associate a certain position with a certain muscular effort, and is of great value in enabling patients to identify by muscular sense the corrected position. The exercise requires but little effort and may be done at home without assistance. It may be modified in various ways by adding free-arm, staff, or dumb-bell exercises, which change the center of gravity,

strengthen muscles approximating the scapulæ, and prolong the corrected attitude.

## ASYMMETRIC EXERCISES.

"XI. *Hip Sinking* (Hoffa).—Position: From the fundamental standing position the patient advances the foot, on the side opposite to the convexity of the lateral curve, forward and outward about two foot-lengths. (1) The patient bends the forward knee, sinking the hip on that side. (2) The patient resumes the primary position.

"A passive side correction of the lumbar curve, due to a lowering of the pelvis on the side of the advanced leg when the knee is bent. Suitable for lumbar curves.

"XII. *Self-correction* (Lorenz).—The patient assumes the fundamental standing position and places the hand of the side to which the dorsal spine is convex upon the side of the thorax opposite to the greatest dorsal curve; the other hand is then placed on the ilium. (1) By a side thrust of the hand on the thorax the patient corrects or overcorrects the dorsal curve, maintaining the correction for a few seconds. (2) The patient relaxes to the primary position. The exercise may be modified by placing the hand on the side to which the dorsal spine is concave on the top of the head, as it thus tends to raise a low shoulder. The rest of the exercise is performed as described.

"A side thrust of the dorsal spine with pressure applied to the convexity of the dorsal curve against resistance furnished by the other hand on the ilium or the head. Suitable for dorsal scoliosis, but not powerful, and useful as a means of stretching; chiefly good because it can be done by the patient unaided at frequent intervals. Exercises XI and XII may be combined for a double curve with one element dorsal and the other lumbar.

"XIII. *Hip Sinking from Stool.*—Position: The patient stands erect on a stool on one foot (the foot on the side of the convexity of the curve). (1) The patient lets the free leg sink as much as possible, thus lowering the pelvis and hip on that side. The knee

of the supporting leg must be kept straight. (2) The patient resumes the original position.

"A passive side stretching of the lumbar curve suitable for lumbar scoliosis. The leg and pelvis drag down on the side of the concavity of the lateral curve, tending to stretch contracted structures and straighten the curve.

"XIV. *Trunk Hyperextension with Side Bending—Lying on the Face.*—The patient lies face downward on a table or on the floor as described in Exercise VI. (1) The trunk is raised from the table as far as possible by hyperextending the spine. (2) From this position the trunk is bent to the side toward which the lumbar curve is convex. (3) Position 1 is resumed. (4) The prone lying position is resumed.

"This exercise is an active lateral flexion of the spine in the position of hyperextension. As hyperextension locks the dorsal region against side flexion, the movement is almost wholly confined to the lumbar region. If there is a right dorsal curve in connection with a left lumbar curve, bending to the left, while it corrects the lumbar curve, does not at the same time greatly increase the dorsal curve, as that part of the spine is locked against side bending. The exercise is, therefore, suited not only to lumbar curves but especially to compound curves in both dorsal and lumbar regions.

"XV. *Drawing up the Hip—Lying on the Face.*—Position: The patient lies prone on a table, holding the end with both hands, the arms extended and the spine and legs in a straight line. (1) The surgeon grasps the ankle on the side of the lumbar convexity and resists while the patient draws the hip up as far as she is able, the knee being kept straight. (2) Position 1 is resumed.

"The approximation of the side of the pelvis and the thorax on the side to which the lumbar curve is convex is brought about by an active contraction of the muscles on the convex side of the lumbar curve which it is desirable to develop. The amount of work thrown on these is determined by the amount of traction made on the ankle. The exercise is suited to cases of lumbar curves or to the lumbar element of compound dorsal and lumbar curves.

"XVI. *Self-correction with Arms Extended Behind Back* (Mick-

ulicz).—The patient stands without pelvic fixation with the arms hanging behind the back, with extended elbows, and the hands clasped loosely with the palms together. (1) The patient bends forward, flexing the spine. (2) The patient then straightens the arms with force, getting the shoulders as far back as possible and stretching the hands down, and then describes a half circle to the right or left to the hyperextended median position. The bend is to the right in right curves and vice versa.

"The exercise is a side flexion made in the direction that improves the lateral curve, made with the shoulders in a corrected position. The arm on the convex side presses against the rotated thorax and has some corrective effect. The exercise is particularly useful in dorsal scoliosis with increase of the dorsal physiologic curve (kypho-scoliosis).

"XVII. *Partial Suspension by One Arm with Other Arm and Leg Locked.*—Position: The patient standing by a ladder or under a bar, that can be reached without rising on the toes, grasps one rung of the ladder or the bar with the hand of the side to which the spine is concave. On the opposite side, the convex, the arm passes under the knee, the thigh being flexed at the hip, and the shoulder and pelvis are thus approximated. (1) The patient thus standing on one leg flexes that knee and allows the body-weight to come upon the arm. (2) The original position is resumed.

"When the arm is placed under the knee the pelvis and shoulder are approximated on that side and the spine made convex to the other side as far as it will go. The structures on the concave side are thus put on the stretch and by allowing the body-weight to come on the arm holding to the ladder, a further stretching force is exerted on the structures on the concave side. The exercise is suited to total and dorsal curves.

## "CREEPING EXERCISES (KLAPP).

"In these exercises the patient supports the trunk in a horizontal position with the hands and knees or feet on the floor. The hands, knees, and toes should be protected by leather pads which are strapped on.

"XVIII. *Symmetric Creeping.*—The hand and knee of the left side are placed close together, with the knee inside of the hand, the head is twisted with the face to the left, and the trunk is rotated

FIG. 68.—Creeping exercise of Klapp. (*Lovett.*)

with the right shoulder upward. The right arm is extended beyond the head and the hand placed on the floor, palm down and fingers forward, as far forward as possible and directly in front of the left knee. The right knee is placed as far back and as near the median

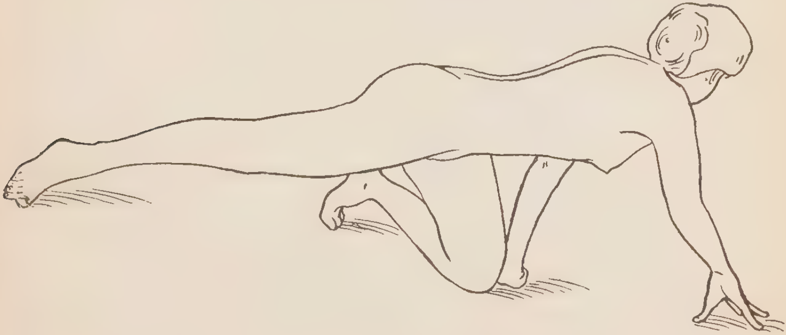

FIG. 69.—Creeping exercise of Klapp. (*Lovett.*)

line as possible; the spine is strongly flexed to the left. The creeping consists of forward locomotion by a series of reversals and regainings of the position described. The mechanism of the first reversal is

as follows: The right knee is drawn forward to the inner side of the right hand in its original place and position, the left arm is extended above the head, and the hand placed as far in front of the right knee as possible with the palm down and fingers front. At the same

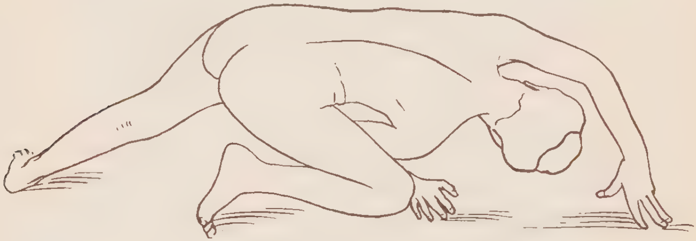

FIG. 70.—Creeping exercise: holding the position. (*Lovett.*)

time the spine is rotated to bring the left shoulder high, the face is twisted to the right, and the spine flexed to the right. The restoration to the first position is secured by again moving the back knee (left) and the back hand (right).

FIG. 71.—Sideways creeping. (*Lovett.*)

"This is a general muscle-strengthening and spine-mobilizing exercise. It is comparatively mild and may be continued for long periods of from twenty to forty minutes. It is said to be of value to lengthen shortened muscles and ligaments on the concave side. Symmetric

creeping is properly that which is done rapidly, and is of most value in restoration of flexibility.

"A modification is made by creeping slowly, holding each position and putting force into the stretching, usually holding the position longest which stretches the concavity of the most marked curve. Another modification is creeping in place, which differs from the above in that the patient does not attempt locomotion. The position is somewhat as above except that the fingers of both hands are placed on the floor, pointing opposite to the side to which the face looks. The trunk is rotated till the side with the forward arm is uppermost, and the arm is carried directly over the head while the under arm is flexed at the elbow which points to the side toward which the face is turned; the posterior knee is straightened, and the part only of that limb touches the floor. The patient then endeavors to look upward beneath the forward reaching arm. This is best employed as an asymmetric exercise to correct the dorsal convexity and stretch the side of the concavity.

"XIX. *Creeping Sidewise.*—There is a third asymmetric variation in 'creeping sidewise' toward the side showing the concavity of the curve to be corrected, for example, in a left total curve. The patient creeps sidewise to the right. The left hand and knee are placed under the trunk, and as far as possible to the right of the right hand and knee. The right hand and knee are then advanced to the right and the above is repeated. The face should look to the left.

"This is a corrective exercise similar to other forms of creeping, and may also be used for dorsal curves as well as for those of the total type."

## CHAPTER IX.

# LATERAL CURVATURES (CONTINUED).

## STRUCTURAL OR TRUE SCOLIOSIS.

Structural lateral curvature is less encouraging to treat. The spine is stiff, the vertebræ distorted, the force of gravity is constantly increasing the deformity during the daytime. The results are often not satisfactory; yet in young children with moderate degrees of deformity complete cures are possible; in older children, great improvement in the standing attitude, and in adolescents and adults, considerable improvement in symmetry of form and general carriage may be expected and obtained.

Treatment must be long continued and demands, on the part of the patient and surgeon, a good deal of time and attention, and necessitates a combination of gymnastics, with the use of machines designed to correct the malposture and the use of corrective jackets. For the severest forms of adult curves, operations have been beneficial in the hands of Hoke.

**Measures to Regain Flexibility.**—Treatment must first aim to loosen up the spine so as to make an improved position possible. A careful selection from the list of exercises already given will guide the surgeon in attaining this object. Lovett finds it essential that the pelvis should be fixed during many of the exercises,—otherwise the movements are general and do not aid in obtaining local flexibility of the spine. Little may be accomplished by these exercises in the severest forms of curves, although Klapp, of Bonn, has undoubtedly been very successful with the creeping exercises which are included in Lovett's list. Daily massage of the trunk at the time of exercising is a help. After flexibility is restored, exercises, which are simple and at the same time corrective, should be devised to suit the case by a well-trained teacher of gymnastics in collaboration with the surgeon. In order to obtain corrective results, the

work must be given under the eye of a competent gymnast for one to three hours a day according to her vigor for many weeks before the exercises at home can be substituted. These usually fail and unless a gain is noted from lesson to lesson should be superseded by forcible correction.

Passive stretching of the spine may be secured by hanging by the arms and by traction on the head; this should always form a part of the daily gymnastic exercises. Many forms of apparatus, like the Beigel-Hoffa frame and the kyphotome of Taylor, exert screw pressure by pads upon the sides of the chest during suspension. Lovett believes more may be accomplished by side pressure when the muscles are relaxed by lying down, for even on a cadaver the lateral correcting force causes a greater spinal displacement when the patient is in the recumbent position than when either horizontal or vertical traction is employed. In many of these machines both traction and screw pressure are employed in the recumbent or the erect position.

FIG. 72.—Advanced right dorsal scoliosis in an adult. (*Lovett.*)

A simple appliance for stretching lateral curvature of the spine by side pressure in prone position is the curvature board used at the Children's Hospital. The patient lies face downward with the knees flexed on a board 3 feet wide by 4 feet long; a canvas strap passes around the upper part of the thorax and it is fastened to a cleat; a similar one passes around the pelvis and is fastened to

a cleat on the same side of the board; while a third is placed between the other two, so as to pull the point of greatest curvature in the opposite direction; the cord from this canvas strap passes through a compound pulley, by means of which any reasonable degree of force may be exerted. The use of this stretching board is limited to correcting lateral deviation—rotary changes are not much influenced.

FIG. 73.—Lovett's correction board for lateral curvature. (*Children's Hospital.*)

A more effective appliance was devised by Z. B. Adams, of Boston, for daily forcible corrections and for the application of corrective plaster jackets.

When a machine is used for stretching, it should be applied for as long a time as the patient can comfortably stand it, which is generally from 15 to 30 minutes daily. Even very severe cases of structural scoliosis have been benefited by this stretching.

**Corrective Plaster Jackets.**—The plaster jackets may be applied under force. For description of the method of application, the reader is referred to Chapter XX, page 339. The object is to stretch contracted structures and improve the curvature by the continuous

application of moderate force. Lovett applies them to patients lying prone with the legs flexed in order to diminish as much as possible the physiological curves in the spine, and thus place it in the most favorable condition for the correction of both side deviation and rotation. He has demonstrated some diminution in the extent of the curves within the plaster jacket by means of the X-ray, but the improved attitude visible to the naked eye is far greater; and some gain from one to two inches in height from the straightening.

FIG. 74.—Apparatus for forcible correction by plaster jackets. (*Lovett.*)

Jackets are often worn for a period of from two to three weeks and renewed as long as further correction is obtained. They may then be made removable and worn except during exercising, or a brace may be used until the trunk muscles are sufficiently developed to maintain the improved attitude which has been secured.

Lately a patient returned who had worn one of these corrective plaster jackets over a year, because she had been away. She had improved greatly both in her attitude, in the amount of rotation and the alignment of her spine. Perhaps this is the better way to treat many.

As after-treatment a removable brace or a jacket is used afterwards and the object should be to maintain the improved position. Though considerable temporary gains may be made by the corrective method, much remains to be done to make the gain permanent. It is first made possible for the patient to be placed in a correct position. Next she must be taught to assume it herself for short periods of time, by her own efforts; and lastly, her muscles must be so developed that she can maintain the improved position constantly. The use of gymnastic exercises should be continued, but the aim is no longer to secure flexibility, but to make the back and trunk strong. Gymnastics for self-correction, for exercising the muscles on the convex of the curve, gymnastics for backward bending, gymnastics with heavy weights, above all, much work and great patience are required, and it is often necessary that some form of retentive apparatus be used to maintain the position until the muscles are strong enough to do it unaided, and it is here that a brace comes in. For description of the brace for lateral curvature see Chapter XXI, page 362.

FIG. 75.

A removable plaster-of-Paris or leather jacket made on a corrected plaster torso is also useful. It is sometimes desirable to cut this jacket into two pieces horizontally, and separating these as much as possible, to have the patient stand in the best corrected position, while the surgeon marks upon the jacket the places where the flat iron connecting bars should be riveted on in order to make the jacket maintain the correct attitude. The brace and jacket may be used to correct; but the best correction by jackets and braces has been obtained in young growing children with congenital curvatures. In such cases the brace is used for years. "As the twig is bent the tree's inclined."

Wullstein advanced the knowledge of lateral curvature materially when he discovered that he could produce lateral curvature in puppies and dogs by keeping their spines bent three months in a

plaster bandage or harness; also when he discovered that strong traction applied to the cadaver sitting combined with obliquity and rotation of the seat and straightening the shoulders could straighten severe structural curves,—a proceeding which he rendered still more effective by the pressure of screw-pads against the side of the chest. He applied this principle to patients, putting them in forcible-corrective jackets applied sitting with very powerful traction, obliquity of the seat, rotation of the seat and shoulder, and pad pressure. These jackets are worn two or three months and followed by the use of a brace.

FIG. 76.—Congenital Scoliosis in brace. (*Children's Hospital.*)

Preparatory exercises and five minute stretchings in the same apparatus he employs daily for six weeks before the application of the first jacket in order to gain flexibility and make it possible to correct in the jacket. The head, shoulders, and neck are included in the jacket, and windows are cut out to give room for the flattened chest to expand on the side of concavity posteriorly, and of the convexity, anteriorly. These Wullstein jackets should be made strong and heavy and the pressure pads are left inside; they should be worn from two to four months as they are not uncomfortable.

In scoliotics, who are flexible with a fair development of muscle, Wullstein applies two corrective jackets, each worn for six weeks, after which he substitutes a removable brace, which holds the back in the corrected position and allows some motion to it. He has the uprights in the lumbar region replaced by strong, spiral, flat, steel springs which allow a certain amount of lumbar motion, but in forward bending, side bending, and twisting, always act to throw the patient back into the correct position. A head support is often used.

The removable brace is worn three months or more, during which time gymnastic exercises and massage are kept up daily. Twice a day the spine is forcibly extended and overcorrected in the machine. If the spine is not corrected by this time, he recommends repeating the procedure, starting with two more plaster jackets, to be worn for four to six weeks, followed by the brace, gymnastics and massage.

In very severe stiff scoliotics, whose muscles are much atrophied, weak and degenerated, Wullstein found it impossible to accomplish any correction in the jacket.

**Operative Treatment.**—Tenotomies for scoliosis have been tried and abandoned. Operations upon the ribs have as yet found little favor, although Hoke, of Atlanta, reported a single case in which, by resecting and overlapping some of the most flattened ribs, dividing others subperiosteally, fracturing others, and forcing the patient into a plaster bed moulded over a much corrected cast, a greatly improved back was obtained after three operations.

## MALPOSTURES OR POSTURAL LATERAL CURVATURES OF THE SPINE.

These curves have been defined as lateral curvatures without bony change. Their importance is very great, for if left untreated they lead to true bony deformity and doubtless many malpostures really represent the unrecognized early stage of true rotary lateral curvature with bony deformity.

The commonest form of lateral curvature among these is the total curve to the left often accompanied by rotation in the lower dorsal spine, a rotation which reversed, that is to say, one in the opposite direction to what usually obtains in lateral curvature; there is a backward prominence on the side of the concavity of the curve and a corresponding flattening on the side of the convexity; this is slight and may be seen only in forward bending. Slight short lumbo-dorsal and dorsal curvatures have been observed but they are always characterized by the fact that the patient can correct them herself or can be taught to do so in a comparatively short time,

and treatment, as we have already seen, is entirely by gymnastics.

The same precautions should be employed for the support of the clothing which is recommended for round shoulders (Page 142). Occasionally when a child on account of some constitutional trouble fails to get strong under gymnastics, a light brace or support is indicated, but this sign is generally that the child needs treatment for some constitutional cause of her debility. The general hygiene of these children must be looked after; overfatigue at school is to be guarded against; it is best sometimes to withdraw the child from school for six months or a year in order to allow her bodily strength to catch up with her growth, for a large proportion of malpostures arise during the rapid growing period of puberty,—a factor often overlooked. Faulty attitudes habitually maintained for many hours have been considered a cause of scoliosis for many years. The violinist frequently developes it, the itinerant harpist, who wanders through the streets with his heavy harp slung over one shoulder, the hotel porter, and the quarryman who habitually carry heavy loads on one shoulder,—all have been known to have deformities attributed to these causes. The faulty position of the child sitting at school has been regarded as one of the most frequent factors in the production of malposture. The way children sprawl at their desks as they write is familiar to all. To correct this, special forms of desks and chairs have been introduced into many public, private schools, which are adjustable both in height and the proximity of the desk top to the sitting child. It was hoped that teaching a vertical hand-writing instead of a slanting one in the public schools would stop this; but figures are lacking, however, to show any diminution in the frequency of scoliosis in children since these reforms were instituted in the schools.

## STOOP SHOULDERS OR ROUND BACK.

What is usually called round shoulders consists in several deformities, of which the main types are the round back, the round hollow back, and forward shoulders. They are all variations from a type which is regarded as normal. The military attitude which has been

described as normal by Staffel is more nearly normal for the adult than the child; while it is a good standing position for all people with crooked backs to strive for, it is not the average or normal attitude of children.

Adequate descriptions of these attitudes in the different periods of childhood have not been formulated, but they are recognized, in a rough way, by all who are familiar with children.

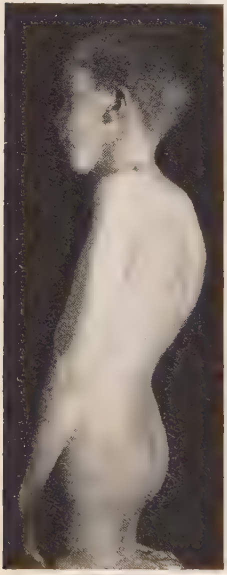

Fig. 77.—Round back. (*Children's Hospital.*)

**The round back** is the expression of muscular weakness. The typical round back is seen in the position of a child in the sitting posture whose back muscles are paralyzed. There is a total kyphosis of the whole column. Schulthess observed it among paralytics, among young children who have had rickets, and in bakers as the result of their occupation, and also among rustics who have for years been digging the ground.

The deformity is a lumbo-dorsal kyphosis with a slight angle or a very short curve above the sacrum; sometimes the apex of the backward convex curve is low in the dorsal region and sometimes fairly high.

The deformity is often associated with a lateral curvature of the spine. Rarely do we see round back when the lumbar spine is straight, or even slightly lordotic, but there is a common type where the lumbar hollow is accentuated as well as the backward curve of the thoracic spine, it is called the hollow round back. Both of these are associated with forward inclination of the head and neck and a moderate forward displacement of the shoulders.

**Hollow Round Back.**—The child with hollow round back sticks his stomach out, stoops his shoulders and may hold the head normally. The causes of hollow round backs are muscular weakness and defects of the eyes or the ears; they may be stiff or flexible,

but are usually stiff if the deformity has been of long standing. There may be an accentuation of the dorsal kyphosis with no change in the other curves of the spine as is seen among children who are bookworms and in old people, but children are more apt to have a much increased lordosis with a relatively slight increase in the normal dorsal kyphosis. The hollow round back may arise from late rickets, or be a late manifestation of rickets in childhood. It is also associated with weakness of the muscles and faulty attitudes from improper clothing or occupation.

A total lordosis of the whole column has been described as a rare affection by Schulthess,—a single long curve concave backward, with the apex at the lumbo-dorsal junction and decreased pelvic obliquity. He found it in paralysis of the muscles of the back, and in lordo-scoliosis; it has been considered a congenital condition. Lordosis is increased whenever it is impossible to completely extend the hips. When lumbar lordosis is increased from any cause, rounding of the dorsal physiologic curve takes place to balance the body, but there are a few cases of lordosis where the spine rises almost vertically afterward. Increased lordosis of the cervical spine with the apex at the third or fourth cervical vertebra is found with the hypertrophic type of arthritis deformans. Lumbar lordosis may extend beyond the lumbar segment and involve the lower thoracic column.

**Forward Shoulders.**—Forward shoulders, as we have already seen may be associated with round back, or may come independently as in the accompanying picture. The cause is weakness, often combined with an improper pull of the clothing on the shoulders.

The influence of clothing is more often seen in girls than in boys. Heavy skirts, petticoats, and stocking supporters are all attached to an underwaist, which hangs upon the shoulder-tips. Although made in many different styles, underwaists always drag upon the outer or movable portion of the shoulders, which, when lowered under fatigue, most naturally droop forward in a circular arc, the radius of which is the clavicle. The weight of the clothing should not hang from the tips of the shoulders but from the base of the neck. A simple device is to put boys into suspenders and have

them crossed in front as well as behind; special waists should be made high in the neck, and sleeveless with a short shoulder, so that the weight has to be carried on the rigid, immovable portion of the shoulder close to the neck. The front should be made loose and easy

A simple method of recording the amount of antero-lateral cur-

FIG. 78.—Hollow round back, from photograph.

FIG. 79.—Forward shoulders, drawn from photograph.

vature has been devised by Lovett. The patient stands with the right side toward a vertical measuring rod on which slides an L-shaped bar which can be raised or lowered to the level of the marked points on the child's body. The following points are marked on child and their height and distance from a vertical upright is recorded on coordinate paper.

The mastoid process, the seventh cervical spine, the seventh dorsal, the fourth lumbar, the middle of the trochanter, the head of the fibula, and the external malleolus. The curve so made in healthy subjects showed very little variation, except that in girls the fourth lumbar was farther forward than in boys. In looking over the curves, four distinct forms are noticed: first, where there is general rounding of the body; second, where a short round back; third, the back is too straight or too hollow; and fourth, where the back is straight but the head is run out forward. When round shoulders are corrected it is the body position which is modified, not the spine.

FIG. 80.—Plaster jacket applied for resistant forward shoulders in a scoliotic. (*Children's Hospital.*)

**Treatment.** — Treatment can almost always be entrusted to a competent instructor of gymnastics under supervision of the physician, but some backs are very stiff and do not quickly yield to exercises. Such may be rapidly improved by forcible plaster jackets. These may be applied on the ordinary hammock frame or the special frame devised by Lovett for the purpose. The shoulders should be included and carefully protected with felt. The jackets should be worn for three weeks and every few days extra felt padding may be put between the jacket and the front of the shoulder-tips to still further correct them. After forcible correction in a jacket, a light brace should be worn for several months to prevent relapse, and gymnastic exercises prescribed daily. For a light brace which is efficient for this purpose see Chapter XXI, Fig. 173. This brace is especially effective in correcting forward displacement of the shoulders and has been

employed for the rapid correction of the stiff deformity instead of plaster jacket treatment.

## DEFORMITY OF THE THORAX INDEPENDENT OF THE SPINE.

**Funnel Chest.**—Funnel Chest, Trichterbrust, Thorax en Entonnoir, Pecho en Embudo. This deformity is characterized by a depression of the median anterior chest wall, the shape of the depression resembling a funnel or a furrow. It may be acquired or congenital and in the latter case has been attributed by Zuckerkandl and Ribberts to the pressure of the chin, for they found that on extreme flexion of the head of a baby two days old the chin exactly fitted the depression, and Hogmann says that the fetus heels may likewise press the sternum in. While many cases are doubtless congenital, many are also acquired, for it was observed to arise as late as the eighth year. Theories have been advanced without proof, such as tardy development and tardy ossification of the sternum, rhachitic disease of the fetus, overgrowth of the ribs, etc.

**Treatment.**—Hoffa attempted by strong adhesive plaster to pull the depressed sternum forward. He also used a suction apparatus fitting exactly the contour of the breast wall, and by it the sunken portion was raised temporarily. Breathing exercises are of value. Deep expirations with pressure of hands on the sides of the thorax, blowing into the mouth-piece of a trumpet, or into a spirometer, are advisable. It would seem that a diminution of the chest capacity must lead to a predisposition to diseases of the lungs, pleura and heart. Chicken breast is almost always associated with rickets and will be considered in Chapter XVII.

## CHAPTER X.

# DEFORMITIES OF CHILD-GROWTH (CONTINUED).

## COXA VARA, COXA VALGA, BOW-LEGS AND KNOCK-KNEES NOT DUE TO RICKETS, FLAT-FOOT, ETC.

### COXA VARA AND COXA VALGA.

Coxa valga has but lately been recognized as a deformity and Coxa vara is still to many a discovery of recent date. They depend entirely on abnormalities of the angle of elevation of the neck of the femur. The average or normal elevation is 125° for the adult and 135° for the child. Variations between 120° and 140° are considered normal; smaller angles are called coxa vara, larger coxa valga.

### COXA VARA.

Coxa vara may originate congenitally or come on during child-growth without assignable cause, or it may arise from trauma, rickets, osteomalacia, or inflammatory bone disease. The congenital form, first described by Hoffa and Helbing, is characterised by some lack of development of the head of the femur. Three boys have it to one girl.

Coxa vara whether congenital, acquired during natural growth in childhood, or through rickets, may present the following symptoms: a limp which is slight or moderate, pain in the leg and thigh which comes and goes, and getting tired easily. On examination there is a little shortening, the trochanter is above the Nélaton-Roser line, and motion at the hip is restricted in abduction only. In double cases there is a marked decrease in the straddle; and in some the adducted hips make him walk as if he had double congenital dislocation of the hips or even like a child with spastic paralysis; lordosis is often increased in double cases and single ones may have

a lateral curvature; if they toe out flat-foot develops. An aid to diagnosis is the test of Trendelenberg; the child stands on the affected leg and the observer notes from behind the position of the buttocks, with a normal hip they remain level, with coxa vara owing to disuse of the abductors of the hip he stands with the hip adducted and in so doing lowers the pelvis and buttock on the unsupported side, while in congenital dislocation of the hip the pelvis sinks on the supported side.

FIG. 81.—Upper part of normal femur. (In the *Warren Museum.*)

In early childhood or in the florid stage of rickets, correction may be made by traction in bed in an abducted position, or by a plaster-of-Paris spica bandage applied in the position of forced abduction under anæsthesia; a supportive splint like the Thomas knee splint or the convalescent hip splint should be worn a year to prevent subsequent bending. To quiet acute pain rest abed, followed by massage and exercises are used, the latter also serve to increase the range of abduction and to strengthen the abductors.

Henle and Mikulicz removed the top of the neck and the adjoining part of the head and of the acetabulum in order to restore abduction. Osteotomies are used for the same object both on the femoral neck and on the shaft just below the trochanter minor; strict aseptic precautions are to be observed; cuneiform osteotomy offers little advantage over linear osteotomy; the same rules and precautions are indicated as in osteotomy for ankylosis of the hip in malposition. The limb strongly abducted is kept in a plaster bandage six weeks;

when the bandage is removed and the extremity slowly brought straight in bed, motion is encouraged early without weight-bearing and a protection splint worn for a year.

**Traumatic Coxa Vara.**—Fracture of the neck of the femur in childhood, though unrecognized till recently, is not an uncommon accident, since radiography has been added to our methods of physical examination.

Fig. 82.—Coxa vara. (*Warren Museum.*)

It differs in symptoms and effects from fracture in later life. The child patient sometimes can walk in a few days, the fracture then is a green-stick one,—a bending or breaking of the neck without actual separation of the fragments; and the limp and discomfort may be mistaken for hip disease. There is always a history of injury, often a fall from a tree, with limping and pain enough to keep the bed several days, it may be even weeks. Shortening from a half inch to an inch shows with a corresponding rise of the trochanter above Nélaton's line. Hip motion is restricted in flexion, abduction, and inward rotation more than in other directions, and as already noted the immediate effects of the injury are less than in the adult. The deformity increases later on because the approach to a right-angled position of the neck exposes it to greater strain, and in old untreated cases the increased shortening and permanent adduction make it indistinguishable from other forms of coxa vara.

The condition has been studied by Whitman, of New York, who first called attention to its importance and frequency.

**Treatment.**—Whitman, if the patient be seen soon or a few weeks after the accident, or before consolidation is complete, attempts to replace the neck in proper relation with the shaft by forcing the limb into extreme abduction and fixing it in this position by a plaster bandage from axilla to toes. This forcible abduction of the thigh may be the means of replacing the neck of the femur in its normal relation with the shaft, because the rim of the acetabulum on which the trochanter impinges acts as a fulcrum, the shaft as the lever, while the lower border of the strong capsular ligament fixes the head of the femur so that the neck is by it bent back into place. When the normal limit of abduction is reached compared with the sound limb, the deformity has been completely reduced. The first plaster bandage should be worn six weeks, after which a short spica bandage with lessened abduction is worn and later a traction hip splint Chapter XXI, page 364. Full use of the limb should not be allowed for four months, or if painful for a still longer time. As a rule, the neck of the femur gives way some distance from the epiphyseal junction in childhood; in adolescents, however, the new bone near the epiphyseal cartilage appears to be the weak point. Epiphyseal separation is rare as compared with fracture of the neck of the femur, according to Whitman; it may occur in adolescence or in childhood, and often in those who already have the coxa vara deformity. Abduction of the thigh would be the attitude most likely to approximate the fragments in true epiphyseal separation also.


Fig. 83. Coxa vara with short neck at 100° with shaft.

Firmly united cases in which abduction is lost, may be cured by sub-trochanteric osteotomy, either linear or cuneiform, and retention in an abducted position. Whitman removes a wedge of bone, leaving a portion of the cortex uninjured on the inner side of the femur, opposite the trochanter minor; the thigh is then gently abducted

and after the trochanter and neck come in contact with the upper border of the acetabulum, further abduction closes the wedge-shaped opening. This attitude is retained in a plaster spica bandage until union is complete. Whitman uses the short hip splint or the Lorenz spica, for, as the continuity of the femur is unbroken on the inner side, there is no danger of displacement of the fragments; he allows the patient to walk upon the limb in a few weeks. This method is only for children. In young adults fracture of the neck of the femur is unusual, and Whitman has found it associated with a back ward displacement of the head or neck of the femur, so that the limb is rotated outward, and there is a marked limp. This rotation as well as the adduction may be remedied by linear sub-trochanteric osteotomy.

## COXA VALGA.

**Coxa valga** is the reverse of coxa vara, a steep inclination of the neck of the femur over 140°. It has been found in about one percent of the femora in museums and may be associated with fractures, infantile paralysis, rickets, osteomalacia, osteomyelitis, knock-knee or congenital dislocation of the hip. David describes a congenital form of coxa valga, and it follows disuse in amputation stumps. Galeazzi describes a hip dislocated by paralysis where a high grade of coxa valga was attributed to the unopposed action of the psoas muscle in skating and walking. The deformity may also arise without apparent cause from growth. It may be double or single, more frequently the latter; it may follow the use of forceps in a breech delivery, causing an epiphyseal separation or incomplete fracture of the neck as reported by Young. It is commoner in boys than in girls.


Fig. 84.—Coxa valga. (*Warren Museum.*)

The diagnostic signs are real lengthening of the leg from a half inch to an inch; an abducted position of the hip with outward rota-

tion; inability to adduct; flattening of the side of the buttock from absence of the fullness of the trochanter; lowering of the trochanter so that the top lies an inch or so below Nélaton's line instead of close below it; and the peculiar gait, leaning far over to the affected side whenever the weight falls on the affected hip.

*The symptoms* in little children come insidiously, the child learns to walk late, or limps leaning far to one side if the deformity be single, or rolls like a sailor if the deformity is double, raising the feet but little and bending the supporting knee before the advanced foot reaches the ground; they fall easily and find it hard to rise; they tire easily, and sometimes have pain and tenderness about the glutei and abductors, and sometimes spasm.

**Treatment.**—David and others under anæsthesia have forcibly adducted and retained the limbs in plaster with inward rotation. Tenotomy has been tried by Young, with fixation in plaster. Galeazzi, of Milan, divided by osteotomy the base of the neck where it joins the shaft, using an anterior vertical incision and closing the wound tight; putting the patient to bed with slight traction and watching the gradual rise of the trochanter by frequent radiographs. When the desired amount of shortening was reached a long plaster spica bandage was applied; walking without weight-bearing was allowed in three weeks. He reports an excellent functional result in two cases a year after operation.

## BOWING OF THE FEMUR NOT DUE TO RICKETS.

The vast majority are due to rickets, but in a certain number it plays no part. The accompanying illustration and radiograph show the condition in a child recently at the Good Samaritan Hospital, Boston. At birth, in order to start respiration, the hot and cold water plunge was employed. Accidentally one leg was dipped into boiling water and cicatricial contraction from the scald flexed the leg on the thigh and almost attached the heel to the buttock. Under the restraint of the scar, the bones grew and after five years anterior bowing was marked. Growing bones owe their shape to external forces and change of shape depends upon the stiffness and resistance of the bone in proportion to the force.

FIG. 85.—Bowing of femur and leg from restraint of cicatrix.
(*House of the Good Samaritan, Dr. A. W. George, Radiographer.*)

### BOW-LEGS NOT DUE TO RICKETS.

The common cause of bow-legs is rickets but it may be seen in vigorous infants who stand and walk early when the force of weight-bearing affects a bone too soft to support the weight of the body. Adolescents get bow-legs from tardy or adolescent rickets. Bow-legs are not uncommon in adults and is the popular attribute of strength and activity. It is said to be common among men who ride horseback; but these people generally do not know that their legs were straight in childhood. Probably any force acting every day on the long bones, whether muscular, static, or due to occupation, may produce in time a curvature even in the bones of an adult, for they, like the soft parts, are continually undergoing changes analogous to growth.

### KNOCK-KNEE NOT DUE TO RICKETS.

Knock-knee is usually the result of rhachitic softening; but it may be due to other forces acting upon growing bone and may express the result of growth under the restraint of the long-standing use of orthopedic appliances in which the pull of some of the straps has been used unwisely; or it may represent an overgrowth of the epiphysis from the presence of bone inflammation in the juxta-epiphyseal region where the increased blood supply causes increased growth. If a focus or foci of bone inflammation be confined to the internal condyle of the femur, for instance, the inner half of the epiphyseal disc of cartilage receives more blood and grows faster than the outer, and results in knock-knee, so it is a common complication of tumor albus.

### BACK KNEE.

Back knee, genu recurvatum. This deformity may be a congenital distortion of the knee-joint, or it may result from rickets or fracture of the femur or tibia, in which case the femur may be curved sharply forward above the joint or the tibia may bend sharply forward just below the head. It may also arise from the effect upon the growth and mechanics of the knee-

joint of an equinus position of the foot, for the attempt to place the heel upon the ground may then induce it, or it may be caused by the use of a traction splint for hip disease, and in some cases of recovery with shortening a backward knee in the sound leg may compensate for the shortening. It is often combined with knock-knee or abnormal mobility of the joint, and may develop from causes unknown and be regarded as an error of the child's growth. It frequently causes no discomfort or a peculiarity of gait. This distortion should be recognized at a glance. Treatment is necessary only when there is disability. A simple caliper splint with leather behind the knee to prevent hyperextension will often allow the ligaments to shorten again to their normal length in a growing child.

FIG. 86.—Talipes equinus and back knees.

Chapter XXI, page 375.

### HOLLOW FOOT.

While hollow foot, non-deforming club-foot, or contracted foot, as it is sometimes called, may be an inherited peculiarity or may often be traced to infantile paralysis or neuritis, it may arise from short shoes or simply come without assignable cause or be the expression of disproportionate growth, for the muscles, fasciæ and ligaments all are shortened as if they belonged to the skeleton of a smaller foot. There are often no symptoms and the high arch is considered beautiful. On the other hand, some have difficulty in getting comfortable boots. The upper leather and the lacing irritate the dorsum and may set up inflammation of the bursæ, or cause exostoses over the cuneiform bones, a condition popularly known as hump foot, pes cavus, pes arcuatus, pes excavatus. Jeanne has described changes in the scaphoid and cuboid also. Calluses and corns may come beneath the heel and the heads of the metatarsals. Pain is transitory and is apt to be in the great toe, the arch or the sole of the foot. The patient turns his ankle easily,

pounds upon his heels and turns the toes out and in some cases strongly in. Dorsal flexion is limited, and the plantar fascia is short. The amount of equinus is so slight that the foot can come to a right angle with the leg but not beyond it. The limitation of dorsal flexion may be demonstrated by asking the patient to flex his foot while standing erect with his back to the wall, when in spite of strong effort the feet remain "glued to the floor."

**Treatment.**—Post-paralytic cases usually need tenotomy of the plantar fascia, of the tendo of Achillis, the flexor longus digitorum and the flexor hallucis tendons, with forcible wrenching or stretch-

FIG. 87. — Hollow foot, pes cavus.

FIG. 88.—Testing a pes cavus, for short tendo Achillis.

ing, followed by fixation in plaster-of-Paris for three weeks and subsequently the use of a club-foot shoe or some similar ambulatory apparatus. Appliances for forcible stretching have been devised by Beely, Reddard and Shaffer, in which forcible correction is obtained for short periods of time daily, and is to be combined with the use of the club-foot shoe. Correction under ether with the Thomas wrench or the Lorenz or Schultze's osteoclast may also be employed without tenotomy and is immediately corrective followed by a corrective bandage, but excepting in little children tenotomies are usually necessary. It is well to incorporate a small thin board, shaped to the outline of the sole of the foot, into the plaster bandage in order that firm, even pressure may be exerted. Massage and exercises should be used during the time the club-foot shoe is worn. These

cases are very apt to have a relapse and may need operation a number of times.

Laurenz has operated for a severe contraction of the foot by excising the scaphoid and the cuboid bones through separate incisions, after trying other procedures in vain. The feet were thus shortened about $\frac{1}{2}$ inch and no motion was permitted where the resections had been done. The result was a very useful pair of feet not deformed.

Another operation was devised by Sherman, of San Francisco, because of the difficulty of holding the foot in position while the

FIG. 89.—Non-deforming club-foot or hollow-foot.
(*Children's Hospital.*)

tendons are sutured; after tenotomy of the fascia and tendons and loosening up with the wrench and hand to correct the deformity, Sherman applies a plaster bandage in the overcorrected position. After it sets, a window is cut from the dorsum large enough to expose the field of operation; the foot is thoroughly cleansed and enveloped in a sterile gauze handkerchief before applying the plaster, so that cutting the handkerchief exposes a clean operating field. He then turns back upon the dorsum of the foot a quadrilateral flap, covering the dorsal surface of the whole metatarsal region. The extensor proprius pollicis tendon is picked up, cut behind the head of the

first metatarsal bone, and turned back from its sheath; the periosteum so exposed is incised and separated to either side; two chromicized catgut sutures, each having a long, strong, straight Hagedorn needle on either end, are passed transversely through the tendon about half an inch from its cut end; then one needle is passed on either side of the bone between it and the reflected flap of periosteum through the sole of the foot and plantar part of the plaster, the other pair of needles are used in the same way; the sutures are tightened and tied on the outside of the plaster holding the tendon tight to the metatarsal and the flaps of periosteum are sutured over it. On the small toes one suture is enough to hold each tendon in place. After the last tendon is sutured the flap is replaced and sutured, a proper dressing is put on, followed by a reinforcing plaster-of-Paris bandage to retain all the dressings and to strengthen the splint, which, unless some reason forbids, is left undisturbed for from six to eight weeks. The foot should be in a position of slight dorsal flexion at the ankle. The only mishap has arisen from using too fine catgut to hold the extensor proprius pollicis tendon. In removing the plaster it is necessary to see that the foot is not fastened to it by unabsorbed sutures.

## FLAT-FOOT.

**Flat-foot,** a generic term, includes all deformities of the foot which have pronation, from slightly weakened or pronated feet to stiff, broken-down feet with convex or "rocker soles." It is also called splay foot, pronated foot, in German, Plattfuss, pes valgus, pes flexus, pronatus reflexus, French, pied bot valgus, pied plat, Italian, piede spianato, Spanish, pie plano.

It is about the commonest deformity the orthopedist sees. About 62 percent arise between the ages of 10 and 25 years and one-third of the cases are found between 15 and 20 years. It is slightly more frequent in boys and young men; and it is more often double than single. The cause may be congenital, traumatic, paralytic, rhachitic, and static. About 90 percent are static, and the rest evenly divided among the other causes.

**Static flat-foot** comes from weak muscles, improper attitudes in

standing or walking, improper restraint from stockings or shoes, often from all combined. In the infant's foot there is a pad of fat, described by Dane, under the bones in the sole which prevents breaking down of the arch during the early days of walking until the muscles get strong to support it. The infant stretches his toes in all directions; both the great and little toe abduct freely from the long axis of the foot and the inner border of the foot is straight. The adult who has never worn shoes has usually the same type of foot, only more muscular; the prehensile toe may be acquired and is much used by some bands of savages. Bootless savages do not always exhibit this form of foot; some stand and walk badly, that is with pronation. The modern boot or shoe cramps and distorts the front of the foot, causes a loss of power, stiff crooked toes, and permits little or no use of the intrinsic muscles of the foot; all this favors flattening and pronation.

FIG. 90.—Flat feet with pronation, and flattened arch. (*House of Good Samaritan.*)

The skeleton of the foot is formed of an outer and an inner arch. The outer consists of the os calcis, the cuboid, and the two outer metatarsal bones; the inner, of the astragalus, scaphoid, the cuneiforms, and the three inner metatarsal bones. The strong articulation between the astragalus and the os calcis joins the two arches, but the joint facets on the calcis are not horizontal; they incline so that they direct the astragalus under pressure forward and inward. In standing the weight forces the astragalus to twist forward and inward upon the os calcis, causing a slight pronation and rolling inward of the foot, and a lowering of the front of the os calcis; and while the outer arch is depressed under load the inner arch rolls slightly inward and away from it. This is the position of relaxation. It is permitted by the inefficiency of those muscles whose tendons cross the sole, the tibialis posticus and peroneus longus.

**Deformity.**—Three deforming factors vary the appearance in flat-foot: (1) the dropping inward of the foot, (2) the flattening of the arch, and (3) the abduction of the front of the foot. In treatment much depends upon the recognition of these factors separately. Slight amounts of fatigue and pain, more often in the leg than in the foot, characterize the slighter degrees of pronation which are called "weakened foot." Abduction of the fore-foot with no flattening and little pronation is also sometimes seen. Marked pronation deformity is called by the Germans "Knickfuss," broken-foot, although the foot unweighted may still be normal in shape. Anatomical studies of the foot by Dane, Lovett, and Cotton show that the amount of pronation is in proportion to the amount of rotation of the astragalus. Looking at the broken-foot from the rear the heel inclines outward and the tendo Achillis is directed in a sweeping curve inward and upward instead of rising vertically. The terminal phalanx of the great toe is often raised off the ground. Patients get tired easily and suffer pain in the foot, heel, sole, base of toes, and calf of leg. They turn the toes out hence a diagnosis can often be made at a glance. The broken-foot which returns to a normal position when relieved of weight may remain such for years, or may soon pass into severe permanent deformity. The commonest cause of this form is undoubtedly bad shoes. Once the position of pronation is assumed other factors act to increase the deformity. If the bones are softened by rickets and the muscles are weak it is easier for deformity to arise, but the majority arise in adolescence from bad static conditions.

**Diagnosis.**—The diagnosis of flat-foot is usually easy. For record an impression made by the sole of the foot on paper is useful; it is made by simply wetting the foot or oiling it, and causing the patient to step on the piece of paper, or paper previously blackened over a candle-flame may be used and the impression "fixed" like a charcoal drawing. Freiberg moistens the sole of the foot with a solution of chloride of iron and stains the imprint on paper; by immersing this paper in a tannic acid solution the stain becomes a durable black. Bradford, Lovett and Dane observe the pressure mark of the sole by standing the patient on a glass top table and seeing the impress in a mirror placed beneath at an angle of 45°.

**Treatment.**—Treatment aims to restore the arch of the foot and prevent subsequent collapse. Severe cases of congenital flat-feet may be corrected in infancy by manipulations, massage, and fixation in supination and plantar flexion, by means of little splints or plaster-bandage. Older rhachitic children with severe deformities require forcible correction and retention in plaster bandages for four or six weeks, followed by massage and exercises and sometimes a plate. Static flat-foot, from bad shoes, requires attention to correct malpositions of standing and walking. Shoes should be provided which adduct or bend the forward part of the foot in. Prolonged standing should be prohibited. Walking should be done always with the toes directed straight forward. The raising of the arch is best accomplished by gymnastic exercises. The following are serviceable:

1. The patient with feet directed forward and slightly separated rises and sinks on his heels, using the toes as much as possible.

2. The patient stands with the tips of the toes pointing as far inward as possible with heels turned out, raises and lowers his heels, retaining the outward direction of the heels.

3. The same exercise is repeated, bending the knees as the heels are raised each time, straightening the knees as the heels are lowered.

4. The patient sits with outstretched knees and rotates the toes in a circle inward, downward, outward and upward.

5. Resistive movements; the surgeon offering the greatest opposition to supination.

6. The patient walks on the outer borders of his feet as if he had club-foot.

Exercises should aim to attain a flexible foot and elastic gait.

Hovorka makes his patients walk along a board six inches wide planed to incline like a barn roof, one foot on each inclined surface. Patients whose occupations make it impossible to avoid long standing should relieve the position from time to time by rising on the toes; they must realize that their own interest and will power must co-operate, as plates alone will not do. A confirmed valgus position frequently requires a support for the sole of the foot which should be used temporarily. The Thomas' and Miller's boot raise the median border of the sole of the foot from heel to toe. Beely raises the

heel only and makes it run obliquely forward on the inner side to support the front of the calcis. A wedge-shaped piece of cork or rubber may be used inside of the boot to raise the inner border of the foot. Plates and pads have been used very extensively for the support of the weakened arch of the foot. They should extend from the heel to the ball of the foot and support both the outer and inner sides at Chopart's articulation. They should be made on a plaster cast of the foot, the arch being accentuated by the position in which the foot is held during the mold taking and further raising obtained by cutting away portions of the cast. Steel, aluminum-bronze and celluloid are the materials. The use of the flat-foot plate is becoming less frequent. It has the disadvantage of making the foot less flexible and causing the patient to rely upon the support of his plate and to neglect exercises.

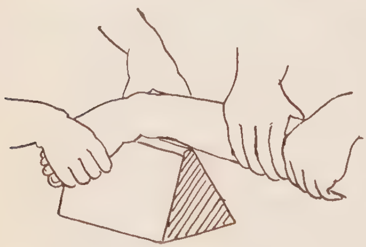

FIG. 91.—Forcible correction of flat-foot under ether.

W. R. Townsend calls attention to the abuse of plates. Many forms of plates are for sale in the shops and advertisements in the newspapers promise instant cure. One should remember that temporary relief may be obtained but not a cure if true flat-foot exists. Though reduction of the deformity may be gained, the patient who fails to cultivate normal movements of his foot will be weakened rather than improved, and a badly fitting support may do harm where a properly fitted one might be of service.

**Severe Grades of Deformity.**—How is a stiff, unyielding flat-foot to be changed into a flexible foot? Forcible correction under anæsthesia usually restores most of the lost flexibility; for a fortnight a plaster bandage maintains the position, after which a strong well-fitted plate will insure bearing the weight on the outer border of the foot, exercise and use should maintain the flexibility. In the less rigid feet a corrective apparatus may be worn for three or four weeks and afterwards a plate on which the patient exercises. That is to say rigid flat-foot is treated by temporary forcible correction and fixation,

followed by correct walking, massage and gymnastics. The Thomas or Beely shoe is often useful. Sometimes it is difficult to regain strength enough to stand on the toes. Some cases of severe fixed flat-foot show considerable elevation of the posterior end of the os calcis with depression of the cuboid; in these feet tenotomy of the tendo Achillis facilitates correction. With care and attention practically all flat-feet undergo great improvement and most are cured. A certain number of surgical operations have been performed for the radical correction of resistive flat feet. (1) Excision of a wedge-shaped piece from the head and neck of the astragalus; (2) removal of the astragalus; (3) wedge-shaped resection of the astragalo-scaphoid joint; (4) linear osteotomy of the tibia and fibula close above the ankle.

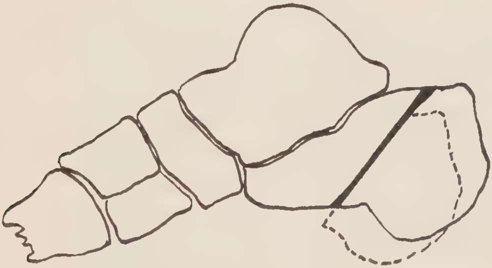

FIG. 92.—Operation of Gleich for cure of flat-foot.

(5) Gleich, Trendelenberg, and Hoffa have tenotomized the tendo Achillis, and then through an incision as for a Pirogoff amputation, have sawed or chiseled through the os calcis from below upward and backward, separating it obliquely into a posterior and an anterior piece, the posterior is slid downward and forward into the sole; this shortens the foot slightly but restores the arch by making the tubercles on the posterior part of the bone lower than the front where it articulates with the cuboid. Excellent results have been obtained by the operation.

(6) Shortening the tendon of the tibialis posticus by the method of Hoffa has also been efficacious.

**By rigid flat-foot** is meant a painful foot with pronation

or abduction caused by contracted muscles, in reality one fixed by muscle spasm. This condition is the result of sprain, generally a sprain of the astragalo scaphoid joint, which may be hot and tender; other joints may be sprained. Lorenz has injected cocain solution into the joint and as soon as it was cocainized the foot could be manipulated into any position painlessly; a plaster bandage retains the overcorrected position for two or three weeks when all sign of tenderness disappears. Rest by strapping, light massage and rest in bed or in a plaster bandage accomplishes the same thing as the cocain.

FIG. 93.—Cicatrix and foot after operation. Figure 92.

**Paralytic flat-feet** are a group by themselves easy to recognize; they are to be treated according to the indications of the sort of paralysis present, for instance, if due to infantile paralysis it is remediable by tendon transplantation provided that a long enough time has elapsed to warrant its recommendation, for no one would do a muscle transference if nature is likely to restore the paralyzed muscles in a few months. If the child be slowly regaining power in the muscles a suitable appliance like the one in Chap. XXI, page 382, may be used until such time as the operation is advisable.

It is in the correction of paralytic flat foot that tendon transference has been most employed.

## PAINFUL FOOT, METATARSALGIA.

While weakness of the anterior metatarsal arch is often seen in static flat-foot it is then a secondary deformity, troublesome chiefly on account of calluses under the ball of the foot; it occurs primarily in the affection called painful foot, anterior metatarsalgia, or Morton's neuralgia. Typical cases of this painful affection have sudden cramp-like pains starting in the third or fourth metatarso-phalangeal joint and radiating to the tips of toes and up the leg. Its sudden

onset may be brought on by a miss-step or by the fatigue of standing a long time and almost invariably it comes only when the shoes are worn. Sometimes attacks are infrequent, in others it practically disables the patient and it is provoked by inappreciable causes. The pain is so great that the patient removes the shoe, rubs and compresses the front of the foot, flexes and extends the toes, and after a while the pain goes, leaving no sign or a very slight soreness over the articulation on deep pressure. The cramp-like pain may be referred to a single or to several adjoining joints or to all the bones of the metatarsal arch.

A disturbance in the normal relations of the distal ends of the metatarsal bones probably causes either a pinching of the plantar nerve between the bones or an abnormal strain upon the ligaments connecting the heads of the metatarsals, due to faulty footwear, insufficient room across the toes and consequent pressure on the metatarsals.

FIG. 94.—Metatarsalgia: no apparent deformity.

The anterior arch of the foot is formed by the heads of the five metatarsal bones and the sesamoid bones beneath the ball of the great toe. The second and third metatarsal bones are slightly longer and on a higher plane than the others. Under the weight of the body in standing the arch is obliterated, to reform when weight is removed. When the arch is weak this resiliency is lost; yet Morton's neuralgia may be unaccompanied by deformity. Whitman considers that abnormal side pressure on the depressed articulations causes the pain, that it is similar to applying lateral pressure to the hand; if the hand is relaxed the metacarpals are folded together and the arching is increased in depth, but if the heads of the metacarpals are fixed in a straight line the compression causes great pain at all the joints. The same is true of the foot. Besides the general effect of narrow shoes, some patients show evidence of an inherited predisposition and some have weakness from an old injury of the foot.

**Treatment.**—Local treatment is to provide a proper shoe wide across the base of the toes so that they cannot be compressed laterally, and some sort of support with a high arch to remove pressure from the heads of the metatarsals. As an immediate treatment a firm bandage suggested by Morton, or strapping may relieve the pain. A pad of felt or leather about an inch in size may be fixed to the sole of the foot with adhesive plaster to prevent depression of the arch. Young has modified this by attaching a pad of sole leather to the outside of the sole of the boot with excellent results. As a rule, a modified plate is a more comfortable support. It should be constructed of No. 19 gauge steel upon a plaster cast of the sole of the foot in which the anterior and longitudinal arches have been somewhat exaggerated by carving. The front of this plate should be at least as wide as the foot and extend forward to the line of metatarsophalangeal joints. Massage and forcible manipulation to overcome restricted motions are of value after joint sensitiveness disappears. Rigidity may demand forcible correction under anæsthesia and a plaster bandage. Morton even resected the neck and head of the metatarsal bone at the seat of the pain leaving the toe to recede Exercises to develop the intrinsic muscles of the foot are a necessary part of treatment. Repeated flexions and extensions of the toes, circumduction of the front of the foot and picking up objects from the floor with the prehensile toe should be employed night and morning.

## PAINFUL FOOT FROM EXOSTOSES.

Painful feet are often due to exostoses which may form most anywhere on the bones and especially close to the insertion of the tendons. Exostoses may be due to a general disease, like gonorrhœa, osteo-arthritis and syphilis, or they may grow from the irritation of bad shoes or repeated slight sprains due to habitual malpositions of the foot. The common positions for exostoses are:

1. Hump foot on the internal cuneiform or base of the first metatarsal.

2. At the junction of the scaphoid and cuneiform.

3. On the posterior part of the os calcis running up along the side of the Achillis.

4. On the inferior surface of the os calcis.

They may be demonstrated by the X-ray, although at times this is almost impossible.

Removal by surgical measures usually offers the best chance for comfort. Often a sole plate with depressions to remove pressure from the exostoses is efficient. The tender points on the sole found in gonorrhœal arthritis are not usually due to exostoses.

The condition known as "policeman's heel," as it is a common condition in all city police forces, may be due either to exostoses under the os calcis, or to a bursitis of the subcalcaneal bursa, or to strain of plantar fascia from flat-foot with the pain referred to its calcaneal attachment. A plate to remove pressure from the tender place and to support the arch affords relief.

## HALLUX VALGUS.

Outward deviation of the great toe is produced by adaptive growth under pressure of boots. In the normal foot the long axis of the toe prolonged backward passes through the heel. The great toe from boot-wearing deviates easily and it is not always a tight shoe which causes it, for the upper leather yields from use, stretches across the metatarso-phalangeal articulations, and presses on the side of the great toe as the foot slips forward and back in walking. Short boots and short stockings aid in producing it. The head of the metatarsal partly uncovered by the phalanx is pushed into a more prominent position under the skin, which thickens and a bursa forms beneath it. Inflammation of this bursa is a bunion. Non-inflammatory hallux valgus produces a gait characterized by pronation and loss of elasticity. Pain and irritation of the bunion joint may be mistaken for gout. Marked degrees of this deformity are seen in adolescents, and adults. Few of our children have a perfectly straight toe after the age of eight years.

**Treatment.**—A slight degree of deformity may be cured by wearing light steel or rubber splint along the inner border of the great toe and foot. Even wearing a pledget of cotton between the great toe and its neighbor may accomplish this if the boots at the same time allow room for lateral expansion of the great toe. The toe

post and digitated stockings are excellent. The foot plate is recommended when the foot is weakened or flat. In severe cases operative measures are adopted. Resection of the joint may be done in several ways.

R. B. Osgood lays bare the shaft of the metatarsal immediately above the head, isolates the bone with a flat metal retractor, passes with an aneurysm needle and silk guide a Gigli saw around the bone and sawing it off, removes the distal end of the bone holding the phalanx in place by a suture of chromicized catgut. This operation, like ordinary resection of the joint, produces a useful foot with some shortening of the great toe.

FIG. 95.—Hallux valgus, great toe underneath.

FIG. 96.—Hallux valgus. Great toe overrides.

Another operation, not a resection, opens the joint by a free longitudinal incision on the inner side, lays bare the whole metatarsophalangeal articulation, and with a strong pair of bone cutters removes the inner aspect of the head and part of the shaft of the metatarsal bone, taking off all that protrudes beyond the phalanx; the sharp edges are pared off with a chisel, the phalanx replaced in a normal position, the incision closed, and the position of the toe maintained by a splint outside of the dressings. Passive motion is

begun in two weeks, and voluntary motions are done early by the patient. Usually in three weeks time, the patient walks with a natural gait, free from pain.

### HALLUX VARUS.

Hallux varus, also called in-toe, pigeon toe, is rarely of importance. It is found with knock-knee and may be a symptom of that affection; it may be congenital or may accompany flat-foot. In young children the use of ordinary shoes is sufficient to correct the deformity.

### HALLUX RIGIDUS.

Hallux rigidus, stiff toe, may be accompanied with slight flexion of the first and extension of the second phalanx, or the joint may be rigid in the straight position. It begins with a slight sprain and painful joint motion; later, swelling and tenderness involve both the joints and the bones. After ankylosis there is atrophy of the soft parts. Its frequent association with flat-foot and with bad shoes suggests that it may result from neglected sprain. At times it follows severe injuries, fractures, comminuted crushes of the foot, etc. Rest and local applications are indicated during the stage of acute sprain; later on, protection with a modified plate.

FIG. 97.—Hammer toes.

### HAMMER TOE.

Hammer toe is a claw-like contraction usually of the second or third toe. The second phalanx is dorsi flexed, the third plantar-flexed, producing a callosity over the upward projecting joint and another over the tip of the toe where it presses on the ground. Bad boots, especially short boots, cause it. It may result from paralysis. Slight cases give no trouble. Later on, the surgeon is asked to amputate.

**Treatment.**—Children and adolescents may be straightened by simple splints and strapping. The toes may be bandaged or strapped to a rigid plantar splint. If it fails to yield it can be corrected by subcutaneous section of the contracted fasciæ and tendons, forcible straightening and fixation with splints and adhesive plaster. There is always a tendency to recontract. The use of splints must therefore be prolonged. In severe cases either amputation or excision of the prominent joint may be done. Amputation of the second toe cures the deformity but it may produce hallux valgus.

König calls attention to marked hammer toes with a contracted foot from short boots in soldiers of the infantry. Subcutaneous tenotomy of the flexor tendon of the great toe with the use of a wooden plantar splint during the three weeks required for the healing of the tendon was sufficient treatment.

Flexed or clawed toes also arise from paralysis, and from hollow foot. The tendons and fasciæ of several toes are shortened. The treatment is the same as for hammer toe.

# PART III.

## AFFECTIONS OF BONES AND JOINTS.

## CHAPTER XI.

## THE BONES AND JOINTS: GENERAL SUMMARY.

Many different processes in the bones and joints are classified as inflammations.

For the sake of explaining, let us see what it is that is injured; the bones and the joints are made of different tissue structures; bones consist of bone, marrow, endosteum, periosteum and articular cartilage; joints of a synovial cavity surrounded by the articular cartilages of the bones, the synovial membrane, capsule, ligaments, and peri-articular structures, the bursæ and tendons; in addition they may contain an intra-articular cartilage or two. Each one of these things separately, and several or all of them may get into trouble in three ways: first, by a mechanical injury and repair; second, by true inflammation from the irritating presence of micro-organisms or of toxins, poisonous matters produced by them; and third, by changes due to disorders of nutrition, whether from impaired blood supply, or faulty metabolism of the tissues of the body, or trophic disturbance due to some disease of the nervous system.

Let us take an example of how each one of these three processes affects the structure of bones and joints.

### TRAUMA AND REPAIR IN BONES AND JOINTS.

**Bones.**—Bones consist of periosteum, cortical and cancellous bone, endosteum, marrow, and cartilage,—all tissues of varying vascularity. Injury of *periosteum* may give rise to simple hyperemia and swelling, to traumatic periostitis, to subperiosteal hemorrhage, or periosteum may be cut or stripped up in shreds by mechanical violence. Injury of *bone* is usually a fracture which may be complete or incomplete, etc.; a small piece of bone may be torn away in the attachment of a ligament or tendon; and, in rare instances, a layer of cortical bone, if close under the skin, may be

so injured by a blow that it dies and is cast off as a sequestrum. In fractures, marrow, periosteum and endosteum, and if into the joint, the articular cartilages are all injured. The process of repair of these conditions is described in works on General Surgery.

**Joints.**—Joints usually consist of a synovial cavity surrounded by articular cartilages, synovial membrane, capsule, ligaments, and peri-articular structures. Injuries and repair are seen in dislocations where all structures suffer somewhat from mechanical violence.

As an instance of the injury of a single tissue in the joint may be mentioned the condition known as dislocation of the semilunar cartilage of the knee-joint. Through some sudden twist or fall, one of these cartilages is uprooted, displaced, and perhaps torn across. The knee is instantly locked in the flexed position, there is great pain, and the joint rapidly fills with serous effusion, nature's method of separating the bones and allowing the cartilage to resume its proper place.

It untreated, it slowly re-absorbs, and after a varying time, the patient goes about again, but is liable to repeat the performance.

In partial dislccations the injury is less serious, but all injuries of joints produce this acute synovitis, which is not, as its name implies, a true inflammation of the joint but an oversecretion of fluid from the synovial membrane due to nature's process of repair. Effusions in the synovial cavity may also be produced by the irritating action of bacteria or toxins, but the fluid then is usually not a clear serum, it is either cloudy or contains fibrin.

After an injury the effusion in a joint may be blood; a joint rarely fills with solid blood as the result of injury unless from a comminuted fracture into the joint, or unless the patient is a born bleeder; bleeder's joints are interesting and the changes which follow in the track of repeated attacks are like those of chronic inflammatory disease or of some diseases of unknown etiology usually attributed to derangements of nutrition.

The first effusions may be absorbed entirely or some masses of fibrin remain. In succeeding attacks, however, this fibrin becomes organized into fibrous tissue and the knee is often subluxated and the process ends in complete loss of motion and fibrous ankylosis.

Injuries of joints are accompanied by injuries of the peri-articular structures, but sometimes these suffer and the joint itself escapes. As an instance of peri-articular injury and repair the student should remember tenosynovitis, a non-infectious inflammation of the sheaths of the tendons usually seen at the wrist and ankle. As the tendons and their sheaths are but slightly vascular their repair is slow. The student should bear in mind the histological appearances characteristic of the conditions of bones and joints incidental to repair.

## TRUE INFLAMMATIONS OF THE BONES AND JOINTS.

These are processes caused by the irritating presence of micro-organisms or their toxins.

**Bones.**—*Periosteum.* True periostitis is due to infection with pyogenic micro-organisms and is associated with infection of the bone, osteomyelitis. Suppurative periostitis may strip the periosteum very extensively and separate it from the whole shaft of a bone, and kill it, unless an exit be made early for the pus. Periostitis from syphilis is a well-recognized part of that disease and leads to proliferation. Periostitis from actinomycosis leads to prolonged suppuration but usually confines itself to the superficial layers of the cortical bone of the jaw, ribs and spine.

*Bone and Marrow.*—**Osteomyelitis** is invasion of marrow of cancellous bone, the cortical bone canals and spaces with colonies of micro-organisms which, by their irritant action, set up suppurative inflammation. This inflammation is confined at first to the bone marrow and endosteum. Periostitis may occur with it, due to a superficial osteomyelitis or a breaking through of deep seated suppuration. The process is destructive; its degree of destructiveness depends upon the virulence of the attacking organism. Necrosis may cause the formation of large sequestra which are not unusual. According to the degree of virulence of the organism we may have an acute, or a subacute, or a chronic form of inflammation. The seat of the first focus of infection is often near the epiphyseal disc in children. In infants and young children where the epiphysis is still largely cartilage and,

occasionally, in older children primary foci of infection may come within the epiphysis, and the substance which is inflamed be either cartilage or the new-formed bone of the center of ossification. Suppurative epiphysitis of infancy soon breaks into the joint so it is called both an acute epiphysitis and an acute arthritis; but the primary seat of invasion is in the epiphysis not the joint. Except in infancy pyogenic organisms rarely attack the epiphysis, tuberle bacilli almost always select the epiphysis. Acute epiphysitis is a very destructive process; unless arrested by providing early drainage for the pus, an entire joint may be destroyed in a week.

**Joints.**—Acute arthritis is an acute septic inflammation or a pus joint arising from septic invasion which may be primary or secondary to some other point of septic inflammation, or be secondary to epiphysitis as we have already seen. Its effect on the joint is even more destructive than osteomyelitis is on the bone, but, of course, the destructiveness varies with the virulence of the infecting microbe. Unless nature or the surgeon provides early drainage, the synovial membrane, cartilage, capsule, ligaments, and ends of the bones themselves may melt away under the suppuration. All the structures show inflammation even in the milder, more subacute forms, where instead of true suppurative inflammation in the joint one finds a slightly cloudy fluid with masses of fibrin.

This condition, spoken of as subacute arthritis occurs as a complication of acute infectious diseases, like measles, scarlet fever, typhoid fever, small pox, etc., although sometimes the acute and destructive pus joint is present in these diseases.

## CHRONIC TRUE INFLAMMATION OF BONES AND JOINTS DUE TO MICRO-ORGANISMS.

Syphilis and tuberculosis are general inflammatory diseases characterized by a granulomatous inflammation. The bones are primarily involved; the joints secondarily.

Hereditary syphilis in infancy may produce extensive destruction from joint suppuration. Syphilitic dactylitis in young children is due to the destructive action of a gumma; both the bone and the joint are destroyed, and it involves one or more of the metacar-

pals, or phalanges. Syphilis in the bones of older children and adults is less destructive, has more of the characteristics of a chronic proliferating periostitis or of a subacute arthritis unless a gumma happens to develop.

Tuberculosis is, likewise, as a rule, more acutely destructive in early infancy than later on. The well known and carefully studied characteristics of tuberculosis of the different joints will be considered separately later.

Extra-articular or peri-articular structures undergo inflammation and simulate joint disease or produce arthritis by a direct spreading of the inflammation. One of the commonest of these peri-articular inflammations is the bursitis or abscess of the prepatellar bursa, known as housemaid's knee. As a chronic process there is the adhesive bursitis of the subacromial bursa which causes chronic stiff shoulder.

## THE AFFECTIONS OF BONES AND JOINTS DUE TO DISORDERS OF NUTRITION, ETC.

The structures of bones and joints may be affected by quasi-inflammatory changes due to disorders of nutrition either from faulty metabolism of the whole body, faulty blood supply, or faulty trophic conditions produced by disease of the nervous system. These conditions are imperfectly understood. It is not known that disorders of nutrition are present in all the diseases classified here, but an intimate resemblance in the symptoms and pathology has led the writer to class them together simply for the convenience of the student.

### DISORDERED NUTRITION OF BONE.

**Bone.**—The periosteum is affected in scurvy of infancy and occasionally in rickets, by subperiosteal hemorrhages which may be very extensive and may denude the entire shaft but its most frequent seat is just above the epiphysis in the long bones. In rickets the periosteum is thickened and beneath it is formed instead of a deposit of true bone, some cartilage and some osteoid tissue mixed. Subperiosteal hemorrhage in rickets occurs chiefly in those rare cases

where fractures occur spontaneously. Both scurvy and rickets are diseases of malnutrition.

**Rickets.**—Rickets is a general nutritional disease of childhood which affects the growth of the bones all over the body. In the long bones there is an irregular proliferation between the epiphysis and the shaft of soft "osteoid" tissue, producing an increased width of bone where the epiphysis and shaft join; the shafts of the bones also are weakened so that they bend under the body-weight or the pull of the muscles. It is a disease of early childhood, 94 percent begin before the age of four years, but there are tardy cases coming late in childhood, and adolescent rickets are sometimes seen.

**Osteomalacia.**—Osteomalacia is another nutritional derangement characterized by the disappearance of lime salts from the bones, leading to softening, bending and fracture. There is a juvenile form which is rare, and an adult form which usually follows pregnancy.

**Fragilitas ossium,** brittle bones, occurs as a distinct fetal disease which is fatal within a year, and as an affection of children which is outgrown. They are characterized by frequent fractures, many of them spontaneous. Those beginning before birth represent a different disease because they show no sign of improvement and the patients die young; whereas, those beginning in childhood become strong later. The bones cast a feeble shadow by the X-ray. The same may be said of some cases of rickets and of osteomalacia—always in all these conditions the bones are thin and atrophic with large medullary cavities. The cause of imperfect bone formation is unknown, but it probably arises from a condition of impaired nutrition of bone.

**Hypertrophic Osteoarthropathy.**—It seems paradoxical to say that disordered nutrition will cause enlargement of part of the skeleton, yet this is undoubtedly what happens in secondary hypertrophic osteoarthropathy, a disease of the bone characterized by hypertrophy and clubbing of the fingers. There is a deposit of layers of new bone in the metatarsals, metacarpals, phalanges and occasionally in the distal extremities of the adjoining bones of the arms

and legs, and is accompanied by an overgrowth of the nails. As its name implies, it is always a secondary condition, a complication of pre-existing chronic disease, most often of the lungs.

**Ostitis deformans** is an affection of the bones of middle and advanced life characterized both by hypertrophy and softening of bone, hyperostosis and decalcification. The legs bow under the body-weight, the bones become thick and large, the back is bowed, the skull enlarges; arteriosclerosis accompanies it almost invariably and may be the cause of the impaired nutrition.

**Acromegaly.**—A condition of hypertrophy of the extremities of the body,—the hands, feet, fingers, nose, etc.; the head is increased in size and all of the tissues may undergo change. The people are often giants. The disease is supposed to be due to irritation of the pituitary gland, which has been found not infrequently sarcomatous. It has been said that the disease of the pituitary gland bears the same relationship to acromegaly that the thyroid does to myxœdema.

## DISORDERED NUTRITION OF JOINTS.

**Charcot's Disease.**—Charcot's disease is characterized by hypertrophy of the periphery of the articular cartilages, with erosion at the points of greatest intra-articular pressure and eburnation of the underlying bone, and by sudden large serous effusions into the joints. Locomotor ataxia is the cause of this affection, which is a neurotrophic disturbance of the joint. A history of syphilis is obtained in many of the cases.

**Arthritis Deformans.**—This disease of unknown origin is characterized by changes in the bones and joints resembling those of Charcot's disease, but unlike it there is no association with locomotor ataxia or any other disease. It occurs in two types or forms, the hypertrophic and the atrophic, which are by some regarded as two separate and distinct diseases; they are here classed as types of arthritis deformans because pathologists usually find evidence of both processes at the same autopsy.

The hypertrophic form is characterized by the formation of exostoses around the borders of the joints; the atrophic, by a thicken-

ing of the capsule and thinning and erosion of the articular cartilages and marked atrophy of the bones and of all soft parts in the region round about. Both forms are chronic and progressive and were formerly called chronic rheumatism or rheumatic gout. Under arthritis deformans were also described the chronic joint inflammations due to infections like gonorrhea, typhoid fever, the exanthemata, influenza, tonsillitis, and many mild infectious diseases, which rightly belong with chronic forms of septic joint disease, and are characterized by effusions in one or more joints with chronic thickening of the capsule and periarticular structures; and when several joints are affected they are all involved in a few weeks, after which there is no further spreading to other joints.

"**Gout** is a constitutional disorder associated with excess of uric acid in the blood and characterized by attacks of acute arthritis and by the gradual deposit of urate of soda in and about the joints." In this country it is a rare disease. Gouty deposits are sometimes found after death in the joints of people supposed to have chronic rheumatism, arthritis deformans, where there was no history of an attack of acute gout.

**Functional Disease.**—The remaining affections of the bones and joints are those in which pathological evidence of damage is wanting. Hysterical joints are not uncommon in childhood and usually represent a neuromemisis, that is a prolonged continuation of the symptoms of an injury from which apparently complete recovery has been made, according to the physical signs. They are therefore classed separately as functional joint diseases.

## CHAPTER XII.

# INJURIES AND DISEASES OF BONES AND JOINTS.

## MECHANICAL INJURY AND REPAIR.

### BONES.

**Periosteum.**—Sub-periosteal hemorrhage or bruising of the bone is a condition frequently seen and little talked about. The extensive typical deformity of new-born infant's head known as cephalhematoma is familiar to all. Through bruising in childbirth, the periosteum of the flat bones of the skull is, in places, raised by blood clots, which are very slowly reabsorbed; meanwhile the periosteum at the margin of the clot, stimulated to proliferate, builds up a hard ridge of bone around the swelling, while underneath the clot, the surface of the bone is eroded, from malnutrition caused by the loss of the little arteries which penetrate the bone from the periosteum to nourish it. The same process on a small scale takes place in a "bone bruise" which always takes several weeks to absorb.

Slighter bruising gives rise to painful hyperemic swelling of the periosteum which has been described as traumatic periostitis, although no micro-organisms are present to excite inflammation.

Occasionally, as the result of operation, small bits of periosteum may be stripped up and left. They may cause considerable disability, for the periosteum slowly forms new bone which may restrict the motion of the joint.

The writer recently saw such a case three months after an attempted reduction of congenital dislocation of the hip by open incision. The reduction had failed and a bridge of bone firmly united the pelvis and femur with the foot unfortunately in a bad position.

**The Tearing off of Ligaments and Tendons with Bone.**—Rarely is a small piece of bone torn off by muscular action in the end of a tendon or ligament. Such is the so-called avulsion of

tubercle of the tibia where, however, the actual separation is very slight.

The tubercle of the tibia develops from the upper epiphysis as a long, thorn-like process extending downward over the anterior surface of the shaft. Ossification begins at puberty, it unites with the shaft in a year or two; it is during this time that avulsions have been reported. The muscular contractions must be very sudden and powerful. It is a rare accident and diagnosis should be corroborated by the X-ray.

In complete avulsions immobilization with the leg raised to relax the quadriceps femoris muscle for six or eight weeks has been the treatment, but one surgeon drilled through the fragment into the shaft of the tibia and left his drill in to nail it there for three weeks. Osgood describes a partial separation of the tubercle which he could demonstrate by the X-ray, although the symptoms were very slight.

**Bone; Traumatic Necrosis.**—In rare instances a layer of cortical bone, superficially placed, may be so injured by a blow that it dies and is cast off as a sequestrum. That this process occurs without infection is a matter of some dispute among pathologists. The following case points to its possibility.

An infant of ten months rolled out of bed, striking the top of the head on the floor; swelling appeared which was treated for six weeks with cold applications; it then increased considerably in size, and a hematoma was drained by the physician. Two months later, the child was brought to the writer at the West End Infant's Hospital, and a thin plate-like sequestrum, the size of a fifty cent piece, removed. Nature's process of casting off necrotic bone and repairing damage is slow, even in infancy.

## JOINTS.

The mechanical injuries of joints are sprains, fractures and dislocations. Joint sprain generally produces what is called in the knee an acute synovitis.

**Acute Synovitis.**—This process is common, one should be familiar with it not to confound it with other processes. From a slight injury, a slip, wrench, fall, blow, the knee swells, or the same may occur in

the hip or in any other joint, but the large size and superficial situation of the knee makes it both prone to injury and easy of observation. The knee is therefore taken as an example of what may happen elsewhere. There is swelling, slight increase in superficial heat, motion is more or less restricted, the joint is habitually held slightly flexed, and the patella is found to float if the fluid is restricted to the space beneath it by the observer's hands which encircle the joint above and below and approach the patella. If untreated it persists for months, nature slowly reabsorbs the effusion and there is sometimes a full return of motion in the joint but often joint adhesions restrict it.

FIG. 98.—Acute synovitis of right knee. (*Children's Hospital.*)

*The Treatment* should consist of immobilization with or without pressure, and rest to the joint; or, immobilization may be combined with massage or in mild cases with free exercising of the joint. The process is sometimes hastened by quick superficial applications of the thermo-cautery followed by strapping. Rest, counter-irritation, massage, and occasional passive movements are all indicated but the process of repair is always slow,—five to seven weeks are required for the knee-joint.

In the hip, a similar condition frequently simulates the early stage of tuberculous hip disease; but the symptoms subside quickly—in the course of five to twelve weeks there is a complete return to the normal.

Simple effusions in sprains of wrist and ankle are common.

Another example of joint trauma and repair is the dislocation of the semilunar cartilages of the knee-joint.

**Dislocation of Semilunar Cartilages.**—The intra-articular car-

tilages of the joint sometimes undergo injury as we have already seen. The knee is suddenly painful and locks itself, as the result of a slight twist; there is excruciating pain, and an effusion is rapidly poured out in the joint. Such is the story of displacement of a semilunar cartilage. The cartilage has torn loose from its tibial attachment,—it may be the internal or the external one but the internal is the one usually affected, and this is usually due to an inward rotation of the femur on the tibia which is fixed by the foot on the ground with the knee slightly flexed; the joint can be bent but not extended beyond a certain point,—it is locked. The attack of synovitis is sudden and sharp and its swelling soon masks the slight prominence made if part of the semilunar cartilage is protruding. It is rare in children; more men have it than women,—young men particularly.

To reduce the locked knee it should be fully flexed, the tibia drawn away from the femur and rotated in and out and the leg quickly extended but not forcibly, while the surgeon manipulates with his thumb the situation of the semilunar cartilages, should prominence be felt. Once in a while the knee refuses to reduce, but usually under anæsthesia reduction is easy and occurs with a click. Should the cartilage again unite to the tibia, all may be well. It may remain torn from its tibial attachment at its two ends or it may be torn across in the middle, or a torn piece may be wholly separated and become a loose cartilage in the joint.

In 128 operations for the relief of injuries of the semilunar cartilages, collected by Tenney, 113 involved the internal and 15 the external cartilage. The immediate after-treatment is like that for synovitis but attacks recur and a more permanent cure is demanded. This may be mechanical or operative. An elastic knee-cap with pads beside the patella, or elastic bandages are of great use in preventing future attacks, but they are not always effectual and are often inconvenient. Shaffer's splint is described in Chapter XXI. It depends for its action upon securing a perfect hinge-like motion for the knee-joint and restricting complete extension and flexion by the use of a removable pin. A pad is also placed over the inner aspect of the knee.

The splint is especially valuable for those cases where the leg would lock from slight causes and stay so for a number of hours. The object of this treatment is to prevent harmful motions and positions for several months, so as to allow the cartilage time to unite again with the tibia.

Operative treatment, however, often appeals to the patient because be believes it surer and quicker. The joint is opened by a vertical incision a finger's breadth to one side of the patella and freely explored; the loosened part of the cartilage is excised and removed, the joint capsule sutured, and the wound closed; fixation in plaster is maintained for two weeks, followed by gentle manipulation and a gradual restoration of the use of the knee.

Not infrequently, at the time of operation, there are found hypertrophied villi growing from the synovial membrane about the region of the patellar ligament which can be removed. Sometimes tabs of fat, which represent a similar process further advanced, are removed.

**Villous Arthritis.**—Villous arthritis designates a condition of the synovial membrane which may be due to injury, often results from strain from flat-foot, or may follow mild forms of bacterial infection, or it may accompany joint manifestions in the course of diseases affecting nutrition. The condition is, therefore, referred to in all three classes of joint affections.

It is common in the wake of simple synovitis or in dislocation of the semilunar cartilages. The knee, shoulder, and elbow are the joints most commonly affected,—the knee especially. The folds of the synovial membrane in the knee, the ligamentum mucosum, and the ligamenta alaria, two fringe-like folds extending from the side of the ligamentum mucosum upward and outward to the patella, are the principal places for the growth of the villi, but sometimes villi grow all over the synovial membrane.

These are at first little slender, warty projections, made up of a few small blood vessels and little else besides a covering of the synovial membrane but as they grow older and larger, the vessels disappear and the slight fibrous framework becomes transformed into fat. Masses of fibrin may adhere to these warty proliferations of synovial membrane.

Clinically, these villi give rise to what is known as dry arthritis, —bending of the joint calls forth creaking and snapping sounds plainly heard with a stethoscope and as a rule no excess of fluid forms in the joint. The affection, especially that which follows slight traumatisms of the synovial membrane. is extremely common and often is unnoticed; but as the folds which are near the patella lengthen out the fringes of villi occasionally are caught between the ends of the bones, in straightening the joint there is a great sudden pain, the joint is locked in a partly flexed position, and a synovial effusion begins to form rapidly. This makes them swell and the fringes get larger and more fatty, and are more apt to be caught again. Frequent repetitions cause the membrane to lose its elasticity and the synovial fringe to grow into a large loose fold with tabs of fat hanging at the periphery; when large it is called lipoma arborescens; in the knee villi are found near the patella although sometimes they form elsewhere on the synovial membrane. The fatty change is not the only one to take place in the tips of the fringes; bits of cartilage and dense fibrous tissue are formed sometimes and the loose cartilages known as joint mice are produced in this manner as they later separate from their attachments. Calcareous bodies as well as cartilaginous ones may originate in this way; or they may grow as little placques between layers on the walls of a smooth synovial membrane. Masses of coagulated fibrin, as we have already seen are frequently attached to the fringes,—sometimes the fibrin may be present in a mass an inch in diameter; these large coagula of fibrin have also been observed after inflammatory effusions in the knee joint, such as tuberculosis and rheumatoid arthritis. They act as a foreign substance inside of the joint and irritate like other loose bodies. Lipoma arborescens is also found in tuberculous disease of the knee-joint.

**Treatment.**—Simple counter-irritation and things which stimulate the circulation in the joint, such as baking, may be employed and, if the fringes are short, this is often sufficient. Partly restricting motion in the knee by strapping is of great value because it limits the range of motion and prevents repeating the pinching of the fringes in the joint. In advanced cases where

this treatment fails, the joint should be freely opened and the fringes excised.

A vertical incision, a finger's breadth from either side of the patella, gives a satisfactory field of operation. With proper aseptic precautions opening the knee-joint is not to be dreaded more than opening the peritoneum. Many are benefited by operation but some are not. The incisions should be sewed tight, (the capsule separately from the skin and subcutaneous tissue), sterile dressings applied, and immobilization in a plaster-of-Paris bandage from toe to groin should be maintained for a week or ten days. At the end of the second week the patient gets up on crutches and the splint is removed twice a day for slight voluntary movements. In the third week, the plaster is discarded, a flannel bandage substituted, and the patient begins to walk upon the knee. Hot and cold douching and massage are useful to get rid of the stiffness and moderate exercise should be enjoined.

## BLEEDER'S JOINT.

Hemophilia is not a constitutional disease but a condition inherited among the males of a family of bleeders, people who readily bleed subcutaneously or from slight wounds, and whose bleeding is difficult to stop.

No cause of the bleeder's diathesis has been found.

It has been traced to the seventh generation and the daughter of a bleeder, though healthy and without bleeding diathesis herself, may transmit the predisposition to her male offspring.

Hemorrhages may occur in a joint or outside of the capsule of a joint and in some instances these are followed by fibrous ankylosis as if from a true inflammation of the synovial cavity.

Absorption of blood clot takes place slowly; fibrin acts as a foreign body, irritates the joint and as a result there is often a chronic villous hypertrophy of the synovial membrane, thickening of the capsule, and erosions of the cartilages; about the periphery of the joint exostoses form or else the bone and cartilage atrophy and these conditions may lead in time to true bony ankylosis. All of these conditions minus the blood are found in arthritis deformans. Atrophy

of the soft parts and subluxation of the knee are common. The condition is usually outgrown in middle life, and the first bleeding is rarely fatal.

König described the clinical appearances. After a second or third attack the joint is swollen, there is fluctuation in the synovial cavity, the capsule is thickened and under it masses of fungous tissue may be felt.

The knee-joint is the one generally involved; the condyles of the femur may enlarge, the muscles of the thigh atrophy, the knee flexes, the hamstrings contract and shorten, and the tibia is often subluxated backward.

FIG. 99.—Subluxation from repeated attacks of bleeding in knee. (*Dr. R. W. Lovett.*)

This appearance of the knee-joint in a patient who showed evidence of hemophilia before, such as excessive ecchymoses, or spontaneous hematomas, is perfectly diagnostic, and should never be mistaken for another condition. But there are less typical cases which may be confusing. For instance, Froelich, of Nancy, had a patient with an attack of sudden severe pain in the region of the groin, with a fever of 103° to 104° F., and a pulse rate of 120; the vicinity of the hip-joint was much swollen, the swelling extended from the groin and the iliac fossa externally down to the knee and along the posterior surface of the thigh; the slightest movement gave intense pain. There was no reddening of the skin. In a few days the symptoms entirely disappeared and by ten days he was entirely well with painless joint motion to the full extent. The unfortunate young man, during his military service, had a subsequent attack which was mistaken for osteomyelitis and drained; he died in two days from secondary hemorrhage.

Some evidence of the bleeder's diathesis is generally noted in childhood. Froelich describes two exceptions; one was 23 and one 17 years when first they showed evidence of being bleeders, and he dubs them, arthritis hemophilica tardiva,—tardy bleeder's arthritis. Both of them were operated for the correction of ankylosed malpositions; healing progressed without hemorrhage except that

a fistula in one leaked bloody serum for several weeks. The joints were full of blood, the synovial membranes and articular cartilages were coated with dark red clot and fibrin, the capsule and ligaments were infiltrated and stained with blood, the cartilage had lost its glisten, had changed from white to yellow, and in spots had become pigmented with gray or black, so that it looked like a mosaic.

**Treatment.**—Conservative treatment consists in preventing malposition by rest and fixation. Complete recovery with good joint motion is very rare. Aspiration of the joint may safely be done for diagnosis. Fatal hemorrhages have occurred from operation on the knee and fatal secondary hemorrhages have followed.

## CHAPTER XIII.

# TRUE INFLAMMATIONS OF BONES AND JOINTS—ACUTE AND SUB-ACUTE.

### PERIOSTEUM. BONES.

**True periostitis** is due to an infection by pyogenic or pathologic micro-organisms; it accompanies infection of the bone and marrow, osteomyelitis, and is said never to occur without some slight superficial osteomyelitis. Suppuration may strip the periosteum from the whole shaft and be very destructive as in the following case.

E. C., a hardy boy five years old, came under the writer's care at the Children's Hospital after four days of intense pain in his left leg. His temperature was 102.4; motion at the knee and ankle extremely painful; the whole leg œdematous, hot, and the skin shiny with pink streaks in it; for three days I failed to determine exactly where the suppurative process was, and then made an exploratory incision over the tibia only to find it healthy; some brawny resistance was then felt deep in the calf of the leg slightly to the outer side, and an incision on the outer side of the leg soon opened the distended periosteum of the fibula; the shaft was floating about loose, the periosteum had not yet broken through but was gangrenous in two spots near the junction of the upper and middle third; the shaft was divided and removed and after free irrigations sutured the periosteal wound leaving the extremities open for drainage. The patient soon developed scarlet fever and went to the contagious ward under the care of Dr. Legg, who in the course of the fever, drained two small pockets of pus. In spite of this, the periosteum secreted a fairly strong bone throughout, except at the two points that were gangrenous, and the child has full use of his leg.

Nichols advises for suppurative periostitis with necrosis of the whole shaft that the abscess be drained and left five or six weeks before removing the sequestrum so that the periosteum may become healthy

and begin bone-forming, as the wound can then be cleaned after removing the sequestrum. All cases of suppurative periostitis are not extensive and one often finds small areas of superficial osteomyelitis beneath localized suppurating periostitis which subside readily when drained.

Among the micro-organisms which cause suppurative periostitis, should be mentioned the ray fungus.

**Chronic Periostitis.**—Chronic irritation of the periosteum with proliferation of the inner layer of cells, producing local new formation of bone, may occur after blows, contusions, occasionally after abscesses of neighboring tissues and most frequently in the course of certain infectious diseases like syphilis; and a sort of general periosteal thickening involving most of the bones of the body has been described as a separate disease, toxic osteo-periostitis ossificans. The symptoms of periostitis, which is really a manifestation of periosteal reaction under an irritant, are constant dull pain over the point of thickening, with occasional exacerbations; sometimes, however, there are no symptoms; the condition may be recognized first in a radiograph.

Chronic periostitis demands no special treatment but one should treat its cause.

**Actinomycosis.**—The ray-fungus, described by Hahn, in 1870, in a cow's tongue, was shown by Ballinger, in 1877, to be the characteristic organism of the disease of cattle known as lump jaw. Ponfick, in 1882, found similar lesions in human beings. The organism may get in through the mouth, the throat, or gastro-intestinal canal; growing at first locally, it extends to soft tissues and bones and after a time through the blood system, produces metastases which are like little abscesses. Like tuberculosis, a focus may begin in the marrow of the bone, causing softening and destruction of the trabeculæ of the bones, but more often it produces little abscesses under the periosteum, particularly of the jaw, the ribs, and upper spine. The infecting organism may be detected in the purulent discharge of sinuses by finding minute yellow points in the fluid which, under the miscroscope, show the structure of the rayfungus. It attacks children and men but is rare hereabouts. In

Bradford's case, where the cervical spine was involved, the skin of the neck and shoulders was riddled with sinuses, but improvement and cure followed the administration of iodide of potassium, which has been considered a specific, like quinine for malaria.

**Osteomyelitis** means an infection of bone and bone marrow by pyogenic or pathogenic organisms. Staphylococcus aureus, citreus, streptococcus pyogenes, pneumococcus, typhoid bacillus, and other

FIG. 100.—Abscess from osteomyelitis of femur. Drawn from photograph.

FIG. 101.—Osteomyelitis of the tibia, from photograph.

organisms have been found in pure culture in bone marrow. Of these, staphylococcus is the one commonly found.

Osteomyelitis generally comes in the shaft of the long bones near the epiphyseal line, while tuberculosis generally begins in the epiphysis. Some cases of osteomyelitis in the epiphysis may simulate acute tuberculosis; but acute epiphysitis or acute arthritis of infants is always pyogenic, not tuberculous. Mixed infections are

common; any bone may be attacked, but the femur, tibia, and humerus and phalanges predominate. It has been produced experimentally in animals.

Although it may come at any age, about one-half of all cases occur between 13 and 17; three boys have it to one girl. Fatigue or exposure to cold and wet are sometimes invoked as causes and it not infrequently follows the exanthemata, usually as a secondary infection of pyogenic organisms. Before the days of asepsis, it arose from sepsis in compound fractures and was often fatal. It is often secondary to furuncle, carbuncle, phlegmonous inflammation, etc.

The process starting in the marrow of the cancellous spaces usually spreads extensively before piercing the dense cortex of the bone. In the shaft, after piercing the cortex, it lifts the periosteum, strips it and may separate it from the entire bone, causing necrosis of the entire shaft; or, it may pierce the periosteum, penetrate into intermuscular spaces, and eventually point in the skin. From the epiphysis it breaks into the joint, causing havoc and destruction and sometimes dislocating it; or the epiphysis may be separated from the shaft. These are extreme cases.

Frequently localized osteomyelitis is less violent, necrosis is more limited, and small sequestra are formed to be slowly cast off. Abscesses bursting externally leave sinuses connecting with areas of dying or dead bone, which will eventually be cast off after being surrounded by an involucrum; the process is slow. Deformities arise from extensive bone destruction, from epiphyseal separation, or from pathologic dislocation produced by distention of the joint with pus. The risk of systemic septic infection, always imminent, becomes less after sufficient time has allowed the inflammation to be walled off by granulations.

**Symptoms.**—The affection begins suddenly with fever, with chills or vomiting, with great pain in the affected bone or limb, and usually with stiffness of one or two neighboring joints. If the infecting organism be less virulent, the onset is more gradual and the symptoms are the same only more moderate. Swelling and tenderness are first noticed; not infrequently, there is reddening and increased surface heat. The patient is pale, has a "septic look" the

white blood cells are markedly increased. The radiograph is a valuable aid in diagnosis. The initial stage of the severe type of the affection may, resemble typhoid fever; but post-typhoid osteomyelitis is not seen before the fourth week of that fever. Mild cases are often miscalled rheumatism, and sometimes the resemblance to tuberculous joint disease is very close. These can only be differentiated by repeated careful examinations and radiographs. It is to be hoped that the examination of the opsonic index of the blood for different forms of bacteria may aid in establishing a correct diagnosis.

**Treatment.**—The treatment is essentially surgical. It should be prompt and thorough. If it were possible to remove or even to drain suppurating foci within a day of the start, months of treatment would be saved. Usually before the surgeon is consulted the destruction from suppurative inflammation has extended over a large part of the shaft, has caused the separation of an epiphysis, or produced dislocation just because it had been considered rheumatism. The surgeon should not fear, if he knows he has before him a well localized focus of disease, to attack and *remove* it early. But if inflammation has already extended to a large part of the bone, he should content himself with *draining* the bone by removing part of the cortex and drilling through the infected spongy portion. This relieves pain and affords an outlet for pus. Loosened sequestra demonstrated by the probe or X-ray may be removed by operation, leaving drainage. The process may end there, for the conditions after removing small sequestra are ripe for repair. In a later stage, when a large sequestrum is surrounded by a firm involucrum of hard bone, repair does not occur and sinuses persist for a lifetime. This condition is called a chronic osteomyelitis with involucrum.

Nichols advises for this the removal of both involucrum and sequestrum by a sub-periosteal excision, stitching and folding the sides of the periosteum tightly together so that the new bone forming from it will grow as a solid shaft and not as a thin tube. In the forearm or the leg below the knee, there are two bones and one acts as a splint for the other during the process of regeneration of bone;

but in the thigh or upper arm, great shortening would occur if complete sub-periosteal removal were attemped, and Nichols recommends here to leave a strip of bone in the deepest part of the wound, stitching the periosteum down on to it; the sutures should be absorbable catgut.

Frequently after operating for osteomyelitis a cavity is left in the

FIG. 102.—Chronic osteomyelitis and involucrum of the upper part of femur. (*Children's Hospital, A. W. George, Radiographer.*)

bone to drain and drain; this unsatisfactory condition has driven surgeons to devise a number of ingenious methods of treatment. One of the most promising is that of Mosetig-Moorhof and consists in filling the cavity as a dentist does a tooth, and suturing the periosteum and skin over it. The filling is a mixture of four parts

of iodoform in three parts each of paraffine and oil sessame; the mixture is fluid at 113° Fahr., but the iodoform has to be kept in suspension by stirring just before it is poured into the cavity which is previously made aspetic and dried of all trace of moisture.

Epiphysitis and a pus joint are not uncommon in babies and will be described under the title of "Arthritis of Infants" (page 197). Clinically one sees a sudden sepsis, high fever and vomiting, with great pain and tenderness made worse on attempting to move; soon an abscess appears and surgical aid should be immediate to prevent further destruction. The knee, elbow or hip is usually selected. Osteomyelitis of the spine is probably not a common affection; the infection here may be of a mild type, may simulate tuberculosis.

**Osteomyelitis of the Spine.**—The following case is an example: A child of eleven months was seen by the writer in consultation with Dr. Chandler, of Medford. There was an abscess in the left loin and a history of ten days of fever, vomiting and crying. After incision, the finger penetrated beyond the transverse process of the third lumbar vertebra and removed from the side of the body a loose sequestrum of cancellous bone almost globular, half an inch in diameter. The cavity was irrigated with sterile water, a small gauze wick was inserted and a sterilized dressing applied. After three days, suppuration had ceased; the wick was removed little by little; the wound healed in two weeks, and a celluloid jacket allowed the patient to be carried around in an upright position. At the end of six months, the back was as flexible as that of any child, and all further treatment was discarded. No deformity or subsequent stiffness resulted.

Abscess from osteomyelitis of the spine may be less easy to reach. Paralysis may be a symptom as it is in tuberculous vertebral disease, due to pressure of pus on the cord.

**Osteomyelitis near the Hip.**—Acute osteomyelitis is less common in the region of the hip than in the lower end of the femur; it attacks the upper part of the shaft and rarely the epiphysis and it occasionally comes on the pelvic side. When the upper juxta-epiphyseal part of the femoral shaft is attacked, separation of the epiphysis

takes place; in some joint suppuration and ankylosis may result from it or spontaneous luxation of the hip. Diagnosis is made from the very acute symptoms which characterize osteomyelitic affections in little children and infants.

A chronic osteomyelitis near the hip is not at all rare, according to Koenig, at whose clinic many hips were excised and carefully examined with reference to this point; it was the real cause of one case in seven or eight of those excised for hip disease. The process is sub-acute, less destructive, and much slower than the acute arthritis of infancy, and resembles closely tuberculous hip disease. We are often unable to differentiate these forms, but there exist many cases of hip disease with atypical symptoms, in some of which a careful radiographic study, and the determination of the opsonic index of resistance to different forms of infective organisms, enable us to differentiate. Cases of hip disease with severe symptoms, acute onset of high fever, leucocytosis, and delirium, however, should always arouse suspicion of either osteomyelitis, or of tuberculous meningitis.

**Osteomyelitis following Typhoid Fever.**—This occurs not infrequently. The lesions are usually small and superficial, an osteoperiostitis—extensive destruction of bone marrow only occurs when there is a secondary infection with pyogenic organisms. It usually comes on late in cases of typhoid fever or during convalescence, as does typhoidal arthritis. Keen tabulated the period of onset in typhoid as follows: before the third week 16 cases, from third to sixth week 66, later on 104 cases. The bones affected were chiefly the femur, tibia, and ribs; but it may attack any bone. Pure cultures of typhoid bacilli are sometimes found even in the old sinuses.

Osteomyelitis following measles, the other exanthemata, and zymotic diseases like pneumonia is not very rare and will be considered with arthritis on page 199.

## TRUE INFLAMMATION OF JOINTS—ACUTE.

**Septic Arthritis.**—Inflammation of the joints from septic infection or after acute infectious disease may be mild or severe, the fluid in the joint may be serum or pus, and the course of the affec-

tion be acute or chronic. Sometimes micro-organisms are in the fluid and at other times only their toxins, as though they had never been there or had died out; the infecting organism may be one peculiar to a general disease, or be any pyogenic organism, or both may be mixed. The original infection may be traced to a scratch of the skin or of the mucous membrane, or it may be secondary to some septic process, a furuncle, carbuncle, cellulitis, erysipelas, abscess, or it may come in the train of infectious diseases like cerebrospinal meningitis, diphtheria, dysentery, glanders, gonorrhœa, influenza, measles, mumps, pertussis, pneumonia, puerperal fever, scarlet fever, tonsillitis, typhoid fever and probably others; like other septic processes it may often be impossible to determine the entrance point of infection.

Fig. 103.—Suppuration in knee joint with osteomyelitis of lower end of femur. Traced from photograph.

Any age may have it, one or several joints may be involved. The process in the joint may be very mild, almost like subacute traumatic synovitis only the capsule is swollen as well as distended with effusion which absorbs slowly and ends in perfect recovery, or the fluid may contain some fibrin which does not absorb, or there may be a growth of villi from the lining membrane of the joint which may change into fat or cartilage and the condition be a chronic villous arthritis; or with the swelling of the membranes a pannus may form and the articular cartilage become fibrillated and in time disappear beneath it; or else the process may be from the start a suppuration of the whole joint. One joint alone may be involved, or within a few weeks several may be affected, when, as a rule, further joint troubles stop appearing in new places.

**Symptoms.**—On account of the variety of infecting organisms and the well-known difference in virulence at different times of the same bacterium, there is the widest range of symptoms. What symptoms are common to infections of joints may be summed up

as follows: Sudden onset of local pain, tenderness to pressure over the joint with impaired function, stiffness and spasm, and if in a superficial joint the other cardinal symptoms of joint inflammation, swelling and increased heat of the surrounding skin are present; and the constitutional symptoms of fever, increased pulse rate, and an increased number of white blood corpuscles, a leucocytosis at first without appreciable fall in hemoglobin. Some lymph nodes usually enlarge and remain so during the period of infection. The history of recent diseases should be heeded and a careful, thorough examination of the whole body be made for a possible entrance of infection. Mild symptoms indicate inflammation without suppuration; early symptoms of a pus joint are the same only much exaggerated, often there is evidence of extensive destruction and of abscess. Late in non-suppurative and more chronic cases infiltrations in the peri-articular tissues and thickening of the capsule are added to the early signs of the process and a secondary anæmia develops which is known by the decrease in hemoglobin index.

But little headway has been made in differentiating by the clinical symptoms between the different forms of infections due to definite micro-organisms.

**Rheumatic Fever.**—Rheumatic fever, if one accepts the Micrococcus rheumaticus as its sole cause, may be differentiated from the rest by the absence of suppuration, although the signs of inflammation may indicate it, and a progressive and successive involvement of joint after joint; and also by its proclivity to excite endocardial and pericardial inflammations with or without joint trouble; the cause of rheumatic fever is still sub judice.

**Acute arthritis of infancy** is a septic infection with definite symptoms and course and it has been considered a separate disease, but one knows that it is caused either by a primary septic arthritis or a primary epiphysitis (osteomyelitis of the epiphysis) breaking into the joint and that the inflammation is produced by the presence of ordinary pyogenic organisms. The following case of acute infantile arthritis of the hip will illustrate what the affection may be.

J. C. entered the Infants' Hospital, aged 14 months. For three days he had vomited, had high fever, and cried out

whenever he was moved. The patient's left thigh was much swollen and fluctuating from the crest of the ilium to the knee A firm resistant mass could be felt in the iliac fossa near the pelvic brim. He had high fever and was evidently very sick. A free opening from the crest of the ilium two-thirds of the distance to the knee let out a large quantity of pus, the abscess cavity extended over the pubic bone into the pelvis; in it the dislocated femoral head lay on the dorsum ilii, there were rough edges of bone in the acetabulum and it was perforated; the head was put in but slipped out at the first dressing and two attempts at reduction in the next week were unsuccessful. Five months later I replaced it by the open method, scooping out and enlarging the acetabulum and removing an exostosis from the neck of the femur which overlapped part of the head. The result was a useful straight hip with only 30° of motion.

The treatment of all acute septic infection of the joints with suppuration is the same as that of infantile arthritis. The earlier surgical intervention is obtained the better; all should be opened by a free incision under complete anæsthesia, preceded in doubtful cases by aspiration for diagnosis, and the cavity irrigated and drained while suppuration lasts. Pyogenic infections of the joints vary in virulence, but it is always safer to drain than not to.

## ARTHRITIS IN ZYMOTIC DISEASES.

Infectious arthritis and infectious osteomyelitis are often so mixed that they cannot be distinguished clinically. Measles, typhoid fever, scarlet fever, pneumonia, mumps, diphtheria, in fact any zymotic disease in which other infections like otitis media have been known to occur, may be attended with osteomyelitis or joint inflammation during the course of the disease or soon after.

**Typhoid Fever.**—Joint disease following typhoid fever has been carefully studied by Dr. W. W. Keen, of Philadelphia, in a book on the Surgical Complications of Typhoid Fever.

He found three types of joint affections in typhoid fever, which he called the rheumatic, the septic, and the typhoid. Of the latter he had records of 142 joints; the affection was both monarticular and polyartic-

ular; suppuration was not common and was sometimes followed by necroisis and a sinus; the joints affected were the hip, ankle, elbow, shoulder and knee. Generally the outcome was a return to a useful joint with some impairment of motion unless they dislocated; but out of 84 patients 43 had a dislocation, and of these 40 were hips, two shoulders and but one knee.

In the spine a definite condition has been described called typhoid spine; first it was considered to be a neurosis or "perispondylitis" it is generally regarded to-day as a destructive osteomyelitis and arthritis of the spine, for at times vertebral bodies are damaged like the deformity from Pott's disease. Cases generally develop a week or more after the subsidence of fever during the first days that a patient is up. There is a gradual increase of the pain in the back which becomes agonizing, and which prevents the slightest motion even in bed and is with difficulty controlled by morphine.

Hyperextension of the spine in a plaster bed or by a plaster jacket affords relief but does not entirely stop the pain which may last two months or more. Both a small knuckle and the prominence of five or six adjoining vertebræ have been noticed and radiographs have demonstrated an abscess about the vertebræ. Some cases recover without deformity, some with a slight knuckle, others with rigidity of the lumbar spine where the seat of the affection is oftenest found.

Porter, of Chicago, reported a case of typhoid coxitis, with skiagrams. The arthritis was ushered in by a chill five weeks after the beginning of typhoid fever with pain in the left thigh and hip, flexion of the thigh, tenderness to pressure, and, near the trochanter, a red spot appeared which discharged thin, yellowish pus. One month later, the other hip was affected similarly and dislocation occurred in the second hip, which was reduced afterward but allowed limited motion, apparently because both acetabulum and femoral head had been largely destroyed.

**Pneumonia.**—Joint disease in the course of pneumonia occurs infrequently. It may come on gradually during latter part of the disease or during convalescence. Joint infections of the diplococcus

of pneumonia, however, frequently occur in children without pulmonary pneumonia, the infection arising from the throat, nose, or ear generally.

Cave collected 31 cases of pneumococcus joints including one of his own; the pain and swelling were limited to a single joint with considerable œdema of the whole neighborhood and redness. There was sometimes abnormal mobility from destruction of ligaments and grating from destruction of cartilage. Recovery was slow and the joint ultimately stiff. A diagnosis should only be made from a pathological or cultural examination of the fluid. Healing takes place rapidly after the joint has been thoroughly opened, complete recovery of function may be expected if the suppuration has only been of short duration.

Non tuberculous infections of the bone marrow and joints may be chronic as well as acute and those following pneumonia form no exception to this rule.

**Gonorrhœal Arthritis.**—Gonorrhœal arthritis or gonorrhœal rheumatism accompanies from 2 to 3 percent of gonorrhœas; it appears in the later stages; one joint may be affected or several. The knee is the commonest, but the ankle, wrist, fingers, elbow, shoulder, hip, jaw,—in fact any joint may be attacked. The affection is always painful and generally slow. The swollen joint is at first uncomfortable later very painful, and is both stiff and weak. When the symptoms are acute there is much joint pain, local heat, thickening of the tissues and muscular spasm, and in very severe cases a pus joint. The gonococci may be in the fluid, in the pus cells of the granulation tissue, or growing beneath the synovial membrane. Mixed infections may be found, or at times no micro-organism at all, because they have died out. Thickening from infiltration of the capsule is always present and the joints may be œdematous, with the skin hot, sensitive and inflamed; ankylosis is a frequent result. The effusion may be serous, sero-fibrinous, or purulent. The sero-fibrinous variety is the commonest; fibrin deposited upon the folds of the synovial membrane may become organized by a growth of vessels from the synovial membrane forming a pannus; the cartilage under it is fibrillated, eroded, ulcerated, or disappears; the fibrin coating the

folds of synovial membrane makes them adhere together; the ligaments may also be involved in adhesive inflammation and the surrounding bursæ and tendons.

Villi grow from the synovial membrane in abundance. In the late stages, the swelling and pain may continue, motion is limited or lost, and the joint fixed in a position of deformity. Some consider any obstinate painful swelling of a single joint suggestive of gonorrhœal arthritis although gonorrhœa is a polyarticular affection as often as not. In the chronic cases gonococci are absent, in acute they are usually present.

The following clinical forms have been described: arthralgia without definite lesion, or with very slight peri-arthritis or bursitis; acute synovitis, resembling rheumatism because peri-articular structures are swollen and the joint distended; peri-arthritis without effusion in the joint; tenosynovitis, around a joint which may or may not be inflamed; purulent synovitis; chronic synovitis with the formation of quantities of granulation tissue, or with a serofibrinous exudate and a pannus and ending in true ankylosis or in fibrous ankylosis.

FIG. 104.—Gonorrhœal arthritis with subluxation.

*Treatment* in the acute stage should include the urethra if there be any evidence of gleet or stricture. The joint should, have rest in the acute stage, or rest and compression, and if there be much fluid it should be withdrawn by aspiration, an examination made for gonococci, and if it be sero-pus or pus, it should be drained.

Obstinate cases demand protection from weight-bearing by apparatus, or fixation in a plaster bandage. Rebellious cases should be incised and washed out with hot sterile water or weak corrosive, and drainage for a week with repeated irrigations has done good Villi should be excised.

Ohlmacher, and others report excellent results in cases of gonorrhœal rheumatism treated by the method of Wright and Doug-

las, by the subcutaneous injection of an emulsion of the dead bodies of gonococci. In one patient the arthritis had lasted four months and in the other four years and many joints were involved.

There is the prospect of the same good results in other forms of joint infections provided that the organism may be recovered from the joint and grown so that the patient may be inoculated with an emulsion of the dead bodies of the bacteria of his own disease.

*Bier's passive hyperemia treatment* has given excellent results in the hands of many, even in long standing, exquisitely tender, sensitive joints. Several turns of rubber bandage are fastened around the limb above the joint tight enough to constrict and redden but not to make the limb blue, cold or to give pain. It is worn from 2 to 22 hours out of the 24. As soon as the pain stops, usually in an hour or two after application, the joint should be gently moved to prevent stiffness

## CHAPTER XIV.

# CHRONIC INFLAMMATION OF THE BONES AND JOINTS —SYPHILIS AND TUBERCULOSIS.

In the more chronic forms of inflammations of the bones and joints, tuberculosis and syphilis, there usually is present both an inflammation of the bone and an inflammation of the joint. Tuberculosis of the synovial membrane doubtless exists as a primary inflammation, but it is rare post-mortem. Careful study of pathologic material shows the synovial cavity was attacked more recently than the bone. Syphilis may attack a joint independent of bone disease, but this is rare, coming as a synovial serous effusion, or in infants as an acute joint suppuration, but hereditary syphilis is always associated with a peculiar change around the epiphyseal disc, while in acquired syphilis, periostitis or periosteal nodes from previous periostitis are present; or, dense ostitis or eburnation of the long bones may be associated. These processes are not dissimilar from the standpoint of pathology, and form a natural group of chronic infectious inflammations of bones and joints, whose chief point of difference lies in the behavior of the periosteum. In tuberculosis its proliferation is not increased and we have marked bone atrophy; in syphilis the periosteum proliferates, thickens and either makes nodes on the shafts of the bones, or the endosteum fills them with dense bone like ivory.

## SYPHILIS OF THE BONES AND JOINTS.

**Infantile Syphilis.**—Parrot calls infantile joint disease of hereditary syphilis an osteochondritis. There is a broadening and an irregularity in the cartilaginous epiphyseal line with enlargement of the epiphysis and little irregular growths from the cartilaginous layer onto the shaft. Separation of the epiphysis may occur, synovitis accompanies it; it is less often serous than purulent. In in-

fancy joint suppuration occurs, articular cartilages are eroded and the joint may be destroyed.

FIG. 105.—Syphilitic eburnation and periostitis. (*A. W. George, Radiographer.*)

Under constitutional treatment the effusion may be absorbed unless suppuration has already begun to take place. Shortening in older children depends on how much damage is done to the epiphyseal cartilage. Separation of the epiphysis is sometimes seen without any sign of inflammation, and the limb hangs useless, flail-like, and apparently paralyzed, the syphilitic pseudo-paralysis of the newborn, of Parrot. Pain and tenderness in syphilitic bones are generally due to periostitis.

**Syphilis in Childhood.**—The metacarpal bones and phalanges are sometimes attacked by syphilitic dactylitis. A slow enlargement and widening occurs, abscess forms slowly and eventually may lead to the disappearance of a phalanx or a large part of a metacarpal bone when untreated. In rare cases, craniotabes may be found. Both syphilitic periostitis and the typical irregular contours of the juxta-epiphyseal region may be demonstrated by the X-ray negatives.

As both syphilis and rickets distort the juxta-epiphyseal region in

little children, the conditions may be confounded with each other. Rotch says that syphilitic bones do not present the spongy bone enlargements peculiar to rhachitis, and rhachitic bones never show the osteophytes of syphilis; a thick dense shaft from hereditary syphilis appearing in middle childhood means overgrowth of the cortex of the bone. The syphilitic joint is distinguished from tuberculosis by absence of spasm, but atrophy of the limb is marked; swelling, slight tenderness and some heat are present.

Syphilitic bone disease marked by overgrowth of bone, attacks the long bones of the lower leg and forearm chiefly; the growth comes from both periosteum and endosteum, the shafts are thick and the bone hard as ivory. The process usually comes under treatment on account of the so-called rheumatic pains in the legs of children who are approaching puberty. The tibia and fibula are usually affected and may show a marked bowing forward. The tibia is usually bowed forward and feels more or less round like a broom handle,—in fact it is not very dissimilar to the tibia of ostitis deformans. The bone is eburnated, heavier than normal, and offers much greater resistance to penetration of the X-ray. Though it is sometimes moderately tender to pressure, it has nothing like the extreme tenderness of osteomyelitic bone. In older children syphilitic joint disease is a serous synovitis which may be very rebellious to treatment.

**Pathology.**—The irregularity of the line between the epiphysis and shaft observed in rickets is exaggerated in a syphilitic bone, and has been described as a *toothed line* instead of a straight line across the bone. This irregularity is due to unequal activity in ossification; some parts of the epiphyseal cartilage proliferate, become provisionally calcified and turn into true bone in a normal manner, while neighboring portions remain cartilaginous, keep on proliferating, and grow far out into the shaft. Sometimes one finds great enlargement and thickening of the whole epiphysis; at other times, the proliferation of the forming layer of the periosteum may thicken the shaft in circumscribed areas, producing lumps on the bone; such are the so-called nodes of the tibia; similar activity of the endosteum causes a deposit of bone on the interior of the shaft which may largely or entirely obliterate the

canal of bone marrow. Thickening and proliferation of the periosteum and endosteum in the shafts of the long bones are readily demonstrated by means of the X-rays.

Gummata may form in the cancellous tissue and in the lower layers of the periosteum of the shaft or the epiphysis. According to Nichols, when a gumma occurs in the spongy bone of an epiphysis near a joint, secondary changes develop in it giving rise to a condition which cannot be distinguished clinically from tuberculosis of the joint or chronic arthritis. The periosteum may be affected by a gummatous growth, especially the sternum, collar bone, and skull, and sometimes large sequestra are found beneath them. A gumma in the marrow of the metacarpals or the phalanges is the sole cause of syphilitic dactylitis. A whole phalanx may be necrosed and the necrosis be attended with proliferation from the periosteum forming an involucrum or spina ventosa.

**Diagnosis.**—The diagnosis is made on the presence of other physical signs of syphilis together with a history of it. The signs of syphilis in infancy are snuffles within two or three weeks of birth, papular and pustular eruptions involving the palms and soles coming on usually within two or three months; the eruptions may consist of macules, papules, pustules, or bullæ, according to the mildness or severity of the infection, or there may be an eruption resembling psoriasis or the so-called "rupia crusts." Enlarged lymph nodes are not characteristic of hereditary syphilis. The nails are frequently affected, a papule or pustule appearing on the skin at the side of the nail, which ulcerates and causes loss of the nail. The first dentition is delayed, the primary teeth decay early; the second teeth may have the characteristic appearance figured by Hutchinson. Stomatitis, fissures, ulcers, and mucous patches may be present in the mouth; and condylomata about the anus.

The osteochondritis of syphilis presents itself clinically as a swelling at the junction of the shaft and epiphysis, of long bones, or as small, local, round swellings, the tumor rises abruptly from the bone; it may be small and globular or may form a ring where the shaft and epiphysis join or the whole epiphysis may be enlarged. The enlargement of the whole epiphysis occurs in adults only.

**Treatment.**—Infant cases should be treated by mercury. Late cases with iodide of potash or with mixed treatment. Inunction is effectual in infants; blue ointment, diluted with an equal amount of lanoline may be applied to a thin flannel band which is left in place for forty-eight hours, or one grain of gray powder may be given three times a day. When destruction of the joints has occurred, drainage, removal of sequestra, and other surgical indications, must be met by appropriate operation.

**Syphilitic Spine.**—Many cases of hunch back reported in syphilitic individuals fail to show whether the knuckle be due to tuberculosis or syphilis. Gummata in or near the vertebræ have been observed at autopsy and also vertebral exostoses of supposedly syphilitic origin. A few cases have been reported, however, where deformity was present and disappeared under syphilitic treatment.

Such a case is reported by Joachimsthal as spondylitis gummosa. The patient, 54 years old, had suffered for a year from stiff-back, and finally had complete inability to lift his head which was flexed on his breast. In walking and standing he supported his chin with both hands. The vertebra prominans was the apex of a kyphos, the angle of which was 45°. His pain was referred to the deformity, also to the lower back which was much hollowed, and walking brought on rigidity of the spine and chest. There was a history of chancre two years before. Mixed treatment produced rapid improvement, both the pain and the deformity disappeared. Joachimsthal believes this an isolated observation.

## TUBERCULOSIS OF THE BONES AND JOINTS.

### CARIES OF THE SPINE.

**Synonyms.**—Pott's disease; vertebral tuberculosis; angular curvature; posterior curvature; antero-posterior curvature; spondylitis; in German, Spondylitis tuberculosa; Spondylarthritis tuberculosa; Wirbeltuberkulose; Pott'sche kyphose; Spitzbuckel; in French, Mal de Pott; Mal vertébral; Cyphose; Gibbosité; in Italian, Ciphosi; Morbo di Pott.

This is a tuberculous ostitis of one or more vertebræ, causing a collapse of their bodies hence the formation of an angular hump of the spinal column. The intervertebral discs are often destroyed by the process, but only in rare instances does tuberculosis affect any part of the arch of a vertebra. Remains of prehistoric man show the deformity which attacks also domestic animals and wild ones in captivity. Hippocrates treated it in 400 B. C., and described different kinds of spinal curvatures. Percival Pott, in 1779, defined it accurately; its tuberculous nature was demonstrated by Delpech and Nélaton, in 1836. It is a common disease; about 1½ percent of all autopsies in Germany and Austria show this deformity; more than one-fifth of all cases of tuberculous bone disease have their seat in the spine; it is slightly more common in boys than girls, and any part of the spine may be diseased. The frequency with which different regions are affected has been variously estimated by different observers. Hereabouts, there is one cervical for three dorsal or five lumbar cases; but in New York, out of 1000 cases, 6.6 percent were cervical, 70.9 percent dorsal, and 22.5 percent lumbar. A history of trauma is obtained in many cases; trauma may be the localizing cause but there must be exposure to tuberculosis, and a general physical condition incapable of resisting its invasion.

FIG. 106.—Caries of spine: upper dorsal. (*Children's Hospital.*)

**Pathological Anatomy.**—It is said to attack the vertebral column in two ways,—either on the surface of the bodies of the vertebræ, or in their interior; the former is rare. A focus of tuberculous ostitis is characterized by the same phenomena in the spine is in other bones. In the bone marrow of the cancellous interior of a vertebral body, granulomata form, anatomical tubercles, containing giant cells and tubercle bacilli, epithelioid cells and leucocytes; they multiply, absorb

and soften the bone and undergo themselves a cheesy degeneration; they may surround healthy areas, cause necrosis of the surrounded bone, and form sequestra of varying size. Liquefaction of the cheesy detritus produces the so-called cold or tuberculous abscess, the walls of which are composed of granulomatous tuberculous tissue. These abscesses may be of large size after they break through the bone and infiltrate the soft parts, burrowing in the line of least resistance, guided by the fasciæ and muscle sheaths; the bone of the vertebral body, weakened by tuberculous infiltration, collapses under the body-weight, the intervertebral discs are attacked and easily destroyed; the size of the hump depends on the number of bodies affected; at the beginning, the hump is small, sharp, and angular; later on, more vertebræ are involved and it is rounded. When the tuberculous ostitis approaches the back of the vertebral body and the spinal canal, the swelling may press upon the cord through its meninges, producing paralysis, or it may press upon the nerve roots in the intervertebral foramina, producing referred pains,—pains referred to the terminals of the compressed nerves. A growth of anatomical tubercles has been seen in the meninges of the cord but not in the cord itself. In some instances the cord has been found flattened, compressed over a small area but other autopsies have shown no diminution in the size of the cord, but an edematous infiltration produced by the local inflammation pressing on the large lymph vessels and veins coming from the cord. Schmaus and Kahler believe that this œdema of the cord

FIG. 107.—Destruction of sixth and part of seventh dorsal. Age 2 years. (*Infant's Hospital.*)

is followed, if it persists long, by a cicatricial fibrous tissue, a sclerosis, which may make the paralysis permanent. Although great destruction of vertebral bodies may be present it is rare for the bones to cause pressure on the cord in Pott's disease.

**Symptoms.**—These are the referred pains, which may mislead; night-cries, which are uncommon; and early paralysis or paresis, which is also unusual. The physician is, therefore, largely dependent on physical signs for his diagnosis. Peculiarities of attitude and gait often pass unnoticed by the parents and the deformity may also.

*Referred pains* depend upon the distribution of the nerves which are pinched; in the cervical region, the pains are in the arms and shoulders; in the dorsal, one finds stomach-ache and girdle pains; in the lumbar, pains in the legs.

*Night-cries* are uncommon in Pott's disease. The pains which cause them are characteristic of tuberculous bone disease. Children, after going to sleep, wake suddenly with a loud cry and either go to sleep again at once or remember no pain. Night-cries are very common in hip disease and fairly so in tuberculosis of the knee. They may come every night many times or only come once or twice a week; there is no regularity, but frequent night-cries indicate that the disease is increasing.

*Paralysis* may come before deformity. It begins with weak legs increased knee-jerks and ankle clonus; but sensation is seldom affected. In all cases of paresis of the legs, of doubtful origin, one should think of Pott's disease and strip the child and examine his back, for even if no deformity has developed, vertebral disease may reveal itself by the stiffness of the back.

*Psoas contraction* and its detection. When a spinal abscess commences to burrow into the psoas muscle, or even when its proximity to the muscle irritates it, muscular rigidity or spasm appears in that muscle; as a result the psoas muscle is thrown into a condition of partial contraction, and the hip is either partly flexed or cannot hyperextend. If the hip is slightly flexed the knee turns out, and lameness results in seeking medical advice.

**Physical Signs.**—Peculiarities of attitude and gait are usually conspicuous; the child walks stiffly to avoid jar, bears most of his

weight on his toes, does not lift his feet high. The position of the body varies with the region affected; cervical disease may give rise to the position of wry neck, or the head may be thrown well back and to one side, or the chin drooped forward on the chest, where the hands frequently have to support it; in the cervico-dorsal and upper dorsal regions the shoulders are raised and squared. There is much more stiffness in *dorsal caries* and the deformity always shows early and affects the shape of both the back and the chest in a typical way. In the lumbar region the child sticks his stomach out "like an alderman," walks with head and shoulders thrown back. These attitudes and gaits are so typical, that one can locate the disease often in those who pass us on the street. The deformity appears early in the dorsal region and is here hardest to control. A very slight degree of deformity establishes the diagnosis at once but the student should learn to recognize Pott's disease before deformity occurs. The precursor of deformity is muscle spasm; all the peculiar attitudes and gaits we have noted are due to rigidity or spasm of the muscles of the back, as may be seen if the child walks about stripped, and is easily recognized as the movements of his spine are tested. Spasm may limit either forward bending, backward bending, side bending, or rotation, but it generally restricts backward bending most. If the child is asked to pick up an object from the floor, his muscle spasm is shown by the way he does it; muscular stiffness in the neck is tested by observing how he nods and extends the head,

FIG. 108.—Cervical caries showing wry-neck position. (*Children's Hospital.*)

turns to the side, etc.; forward bending of the trunk and neck by asking him to sit on the table with the feet straight before him and grasp his toes; backward bending and side bending of the trunk by having him lie on the face while the observer, grasping the ankles, bends the knees, and slowly raises pelvis, when the normal sagging is lost; by carrying the ankles to the right or left, muscular resistance to side bending can be seen.

Any examination of physical signs for suspected Pott's disease is incomplete without a search for the two common complications, abscess and paralysis. The back of the throat, sides of the neck, iliac fossæ, loins, Scarpa's triangle in the thigh, and the region of the gluteal fold should be observed and palpated for swelling and deep resistance due to abscess. Psoas contraction produces a loss of hyperextension of the hip. Hyperextension of the hip is tested by having the child lie on his face on a table while the observer grasps his ankles and lifts each alternately to detect restriction of hip motion. Psoas contraction produces lameness partly compensated for by the child's walking on his toes.

To test the knee-jerk and ankle clonus for early paralysis, one merely taps with the finger tips or the ulnar border of the extended hand the patellar tendon, as the knee hangs flexed during the test with the muscles relaxed; for the clonus the knee should be straight and the observer, grasping the foot in plantar flexion with the fingers under the ball of the foot, suddenly brings the foot into dorsal flexion and notes any succeeding contractions of the gastrocnemius which occur. One should be familiar with the normal knee-jerk in order to appreciate if it is increased.

**Complications.** The complications of Pott's disease are abscess and paralysis.

*Abscesses* in Pott's disease are at the start tuberculous but may become infected later,—mixed infections. At first confined to the bone, they may break through it and become very large, dissecting a space for themselves wherever resistance between muscles and fasciæ is least. The routes of pus-burrowing vary for different parts of the spine, but all abscesses do not travel far,—some remain small, cease to grow, become eventually encysted and calcareous

or undergo resorption. In the upper half of the cervical region the space behind the pharynx is commonly invaded and a retro-pharyngeal abscess bulges the posterior pharyngeal wall forward, interferes with deglutition and respiration, and makes the child carry its head in a peculiar, semiextended position. If the symptoms are not urgent the abscess may pass unrecognized until it invades the loose tissue in the neck and becomes superficial behind the angle of the jaw, where some prefer to attack it. Abscesses starting from any part of the cervical spine may displace the œsophagus, larynx, and trachea forward, invade the loose tissues within the deep cervical fascia and present on the side of the neck; they may also descend into the posterior mediastinal space, have even been known to dissect their way downward along the aorta, iliac vessels, and present in the front of thigh,—the longest course ever taken by an abscess. The Germans call cold abscesses, Senkungsabscessen.

Abscess likewise from disease of the dorsal vertebræ may invade the posterior mediastinal space, where they give rise to attacks of dyspnœa from pressure on the recurrent laryngeal nerves. They seldom penetrate the abdominal or pericardial cavities but may follow the great vessels down to the iliac fossa, to Scarpa's triangle, to the anterior abdominal wall, scrotum or pelvis. They have been known to break into the bladder, rectum, or ischio-rectal fossa; they may also follow the sciatic nerve from the pelvis and present at the gluteal fold.

In low dorsal disease pus often gets into the psoas muscle, travels within its sheath, pointing either in the iliac fossa, or in Scarpa's triangle. From the lower dorsal region, pus may infiltrate posteriorly and appear as a lumbar abscess on the back.

Abscesses starting from lumbar caries may also present in the same places, in the loin, the iliac fossa, or in Scarpa's triangle; they have, in rare instances, perforated the sigmoid flexure of the intestine.

Abscesses starting from the sacro-iliac junction and the sacrum may point either in the ischio-rectal fossa or superficially over the sacral region and buttocks.

Abscesses occur in about one-fourth of all cases. The cause of abscess has already been alluded to under Pathological Anatomy.

*Paralysis.*—The paralysis is a motor one, usually without sensory disturbances, and rarely are the bladder and rectum affected. In cervical caries, the arms and muscles of the trunk are seldom involved. The paralysis always paraplegic, is usually incomplete, a paresis. Children walk around, but want to lie down a good part of the day, they easily trip and fall, find difficulty in going up stairs, and sometimes totter. Their knee-jerks are greatly increased and ankle clonus is present even when the paralysis is slight. Duration

FIG. 109.—Method of taking an outline of spine with Young's tracer.

of paralysis is variable,—it usually lasts two or three months, and may be recovered from after two years. About one-fourth of the children attacked by the disease have paralysis. A child is likely to have several attacks if he has it once.

**Diagnosis.**—Diagnosis of Pott's disease offers no difficulties if deformity be present. Early recognition may present some difficulty and the history of the symptoms is never suggestive. The diagnosis is made chiefly on the physical examination. Before deformity comes, there is muscular spasm of the spinal muscles which gives rise to a peculiar attitude and gait, and an intelligent study of these postures shows that it is the stiffness of some part of the spine which produces them. Muscular spasm is detected by certain tests. These are, to ask the patient to pick up an object

from the floor, to have him sit on the table with the knees extended straight ahead and grasp his toes, lie on the face while the surgeon lifts the legs and bends the trunk, first backward and then from side to side; to this is added the examination of the neck for stiffness in the muscles by nodding and extending the head and side turning. Two other factors may embarrass the early diagnosis of Pott's disease —they are lateral deviation of the spine, and paralysis before the coming on of deformity.

*Lateral deviation* may be mistaken for lateral curvature. It may precede the appearance of deformity, but in Pott's disease it is always associated with spasm and rigidity of spinal muscles and a leaning of the trunk to one side without any curving of the spine, and rotation of the trunk is very seldom observed. The slightly raised temperature which characterizes tuberculosis of bone is also an aid in the diagnosis of doubtful cases.


FIG. 110.—Tracing of spine of another child.

*Paralysis appearing before the deformity* has often been misleading. It is to be suspected when increased knee-jerk and ankle clonus are found in association with rigidity of the muscles of the back and neck. The temperature chart and the X-ray picture are good guides to follow.

*Deformity.*—The presence of deformity while it makes diagnosis plain, entails the necessity for a reliable record of the degree and amount of deformity, for it is obviously necessary to know at some future visit whether the deformity has increased or receded. This is easily done by making a tracing of the outline of the spine as the child lies prone on the table, cutting from it a pattern in stiff paper or leather-board and trying on and if necessary recutting and fitting it. This pattern can be kept and tried on at any time, first placing the child in the original position. To make a tracing a strip of lead may be pressed down on the spine, carefully lifted and laid on edge on a sheet of paper, and traced; it should be a half or three-quarters of an inch wide and eighteen inches long, and about an eighth of an inch thick so as to be firm

to keep its shape. An ingenious devise is the one shown in the illustration made by Dr. E. B. Young, of Boston; it consists of a wooden bar with a slot in which a number of pieces of wood of equal length play, which are clamped in place by a screw at one end.

**Diagnostic Difficulties.**—Cervical caries may be mistaken for torticollis, sprain, stiff wry-neck from inflamed glands, etc. Sometimes a correct diagnosis can only be made by watching the temperature, the location of rigidity, by increased knee-jerks and ankle clonus, by pains referred to the terminals of the nerves, and by a careful examination by palpation to detect the presence of a possible abscess. Again, the X-ray and temperature chart are of assistance. Round shoulders with stiffness is sometimes hard to differentiate but the absence of real muscular spasm and watching the temperature are usually good guides for diagnosis.

In the lumbo-dorsal region of the spine, a rounded kyphosis which is seen in the florid stage of rickets, the rhachitic spine, may be misleading in little children, but here, too, muscular spasm and a rise of temperature should be absent from rickets. Appendicitis and other intra-abdominal inflammatory conditions have been found in rare instances to simulate lumbar caries or vice versa. While abdominal conditions characterized by great pain, tenderness, and spasm of the abdominal muscles may produce a spinal rigidity from spreading of the muscular spasm, it is very rare for the spasm of the dorsal muscles in Pott's disease to extend to the abdominal muscles. In a few cases, twelve to twenty-four hours of watching has been necessary before the true nature of the condition could be made out. But psoas abscess with acute inflammation of iliac lymph glands may simulate appendicitis closely.

Arthritis of the spine is rarely mistaken for true caries because pain, sleeplessness and nervousness, are much in evidence as they also are in the typhoid spine but here the presence of the Widal reaction is conclusive.

Cancer of the spine may simulate Pott's disease in old people, but the pain is very severe and generally it is in the back; collapse and weakness come on early and the downward progress is rapid.

Spondylitis deformans is characterized by a stiff straight back in

adults and here, too, the pain is chiefly in the back. The diagnosis may be demonstrated by the X-ray.

Repeated examinations may be necessary to differentiate between the neurasthenic or railroad spine and Pott's disease. Atypical symptoms, the absence of reliable physical signs, and a persistently normal temperature,—these three are sufficient to exclude tuberculosis of the vertebræ.

**Prognosis.**—Cases of cervical and lumbar caries recover sooner and with less deformity than do the dorsal ones, and are often well in three years. The tendency to deformity is less because the diseased portion of the spine starts in a physiological lordosis. Good care, early treatment, absence of fever at the time of onset—these are favorable signs: Progressive and rapid growth of abscesses and the rapid development of great deformity are unfavorable. Pulmonary tuberculosis, acute miliary tuberculosis, prolonged suppuration with amyloid degeneration of the spleen, liver, and kidneys and exhaustion—these are the causes of death. With good care the mortality is small. Tuberculous meningitis claims much fewer victims in Pott's disease than it does in hip disease. Those with large abscesses have a poor prognosis. As to paralysis, about 85 percent of paralytic cases recover entirely. The prognosis as to the extent of ultimate deformity depends largely upon the amount present at the beginning of treatment and the kind of care given the child. One cannot ordinarily hope to improve or do away with deformity but one should always prevent its becoming worse, and in many cases, improve the general bearing and attitude.

## TREATMENT.

Treatment is divided into general and local treatment.

**General Treatment.**—Hygiene and care takes the place of drugs, and the general treatment is the same as for tuberculosis of the lungs. The patient should have an abundance of nourishing food, fresh air day and night, out of doors if possible, even in winter, and the activities be restricted by the indications of the temperature chart. All these should be attended to, and then the child may be out, wearing a brace or jacket which fixes the spine sufficiently.

This treatment should be persisted in for several years until convalescence is accomplished. As braces are at best mechanically imperfect, recumbency is employed at times to reduce traumatism of the spine to a minimum. For how long this should be done, is a matter of opinion, for many are in favor of keeping all cases of dorsal caries, which remain in good health, on their backs until the stage of convalescence is about over, in order that they may be spared deformity; others consider recumbency for months and years as unphysiological for a child, preferring as a half-way course ambulatory treatment, tempered with daily periods for lying down.

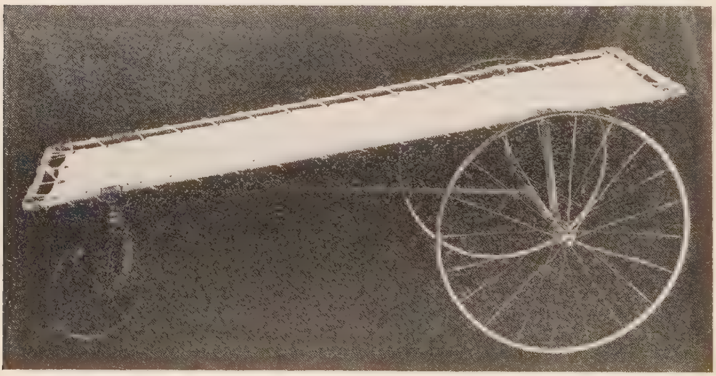

FIG. 111.—Go-cart made on the wheels of a child's tricycle. (*Children's Hospital.*)

The go-cart is a great help, as it does away with the irksomeness of lying in bed and enables the patient to move himself about out of doors. At the Sea Breeze Home, Manhattan Beach, a small donkey is occasionally attached to the go-carts and the little patients on frames drive him about the beach. Sleeping out of doors in a tent or shed can be done in New England the year round, if arranged to protect from the wind and weather, and enough warm clothing and bedding be used in winter and some sort of heating apparatus be employed in the shack in which the patient sleeps. This has been done for five winters at the Convalescent Home of

the Children's Hospital, at Wellesley. The sheds in which the children sleep are often below 20° F., but there is steam heat, and either side can be kept open. The improved color, appetite, and strength of children living out in these shacks, are in marked contrast to the condition of those in the hospital ward. They all gain markedly, both in weight and in the percentage of hemoglobin, unless an abscess is coming.

The use of drugs is as unsatisfactory as in pulmonary tuberculosis. Koch's tuberculin promised much but accomplished little for tuberculous bone disease. It is now receiving a new trial by those who are studying the effect of Koch's new serum upon the opsonic index for tubercle bacilli. Two little children have received this treatment under the writer's care recently at the House of the Good Samaritan, their general health is greatly improved, their opsonic index for tubercle bacilli has been raised, and they are apparently doing well.

It is probable that open air, rest, and increased nutriment may affect the phagocytic power shown by the opsonic index in the same way that the small subcutaneous doses of tuberculin do.

FIG. 112.—Low dorsal caries with lumbar abscess.

**Local Treatment.**—Local treatment aims to improve the form of the spinal column, to fix it, as it were, in splints and hold it there. Recumbency in addition removes the harmful effect of the body-weight, but proper recumbency for Pott's disease is secured only by means of apparatus,—lying in bed does not do it.

**Recumbency.**—The indications for recumbency are, (1) whenever the symptoms are very acute; (2) when the child's condition under ambulatory treatment is unsatisfactory; (3) when paralysis is coming or is already present; (4) when lateral deviation or psoas contraction makes the support inefficient.

Of the various appliances for securing recumbency in bed in Pott's disease, we will mention the bed frame of Bradford, the stretcher frame of Whitman, and the plaster bed of Lorenz and Hoffa.

*The bed frame of Bradford* maintains a horizontal recumbent position. It is a rigid rectangular frame, usually made of four pieces of $\frac{3}{4}$-inch galvanized iron gas pipe screwed into an elbow at each corner; one of the elbows has a reversed screw thread to allow of putting the whole together. The frame should be as wide as the distance between the tips of the shoulders, its length exceeds the height of the patient by a few inches. It is covered with cotton sheeting, double thickness, put on in two pieces with a four inch space between them. The covers should be cut three times the width of the frame; doubling makes them $\frac{3}{4}$ width so that they may be tightly laced on the back of the frame, with a sail needle and stout cord. The four inch space between the upper and lower covers permits the use of the bed-pan without disturbing the position of the child. Two folded linen pads are laid lengthwise on the frame with a space

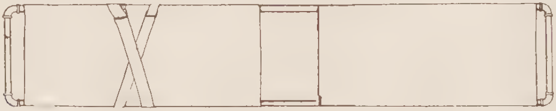

Fig. 113.—Bed frame of Bradford.

between to prevent pressure on the spinous processes; they raise and hyperextend the spine. In putting the child on the frame, he should lie on his side, the frame already padded is placed against his back while the nurse's hand, pressing upon his chest, holds him firmly against the padding and the frame is slowly tipped down flat upon the bed; he wears an undershirt, a cotton or cotton-flannel night-gown, opening behind. To prevent his twisting and turning, two webbing straps are buckled around the child and the frame like a soldier's cross belts, a towel is pinned around the pelvis and frame, and in lumbar disease, a second towel around the knees; an empty pillow case or a very flat hair pillow is allowed. Lying face down, the back is bathed morning and night with alcohol and powdered with talc. Liquids are given through a tube or "feeding duck," and a child soon learns how to eat. While on the frame, he is easily wrapped in shawls and blankets, sent out doors in a go-cart, or carried out for a drive. The only real difficulty

in having such children sleep out in cold weather, comes from the little ones who need frequent changing in the night.

*The stretcher frame of Whitman* is much narrower and it is bent to make the back hollow. It is similarly made of gas pipe, four or five inches longer than the child but only four-fifths of the width of the ordinary bed frame,—that is, the sides of the frame are under the glenoid cavities and the acetabula. The cover is a single piece of stout canvas tightly laced on the back of the frame from end to end. It is well to apply a bandage tightly about the frame where the trunk will rest, to give firmer support, before the cover is put on. Three or four buckles are sewed on the under side of the cover near the side

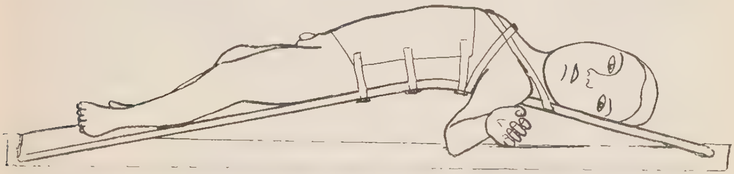

FIG. 114.—Stretcher frame of Whitman.

bars to attach an apron like the apron of a back brace. Felt pads, $\frac{3}{4}$ of an inch thick, are sewed to the canvas so as to press on either side of the spinous processes and protect them from rubbing. The frame is bent to hyperextend the spine,—at first very little,—increasing the bend from day to day until both the deformity and the physiological dorsal curve are completely obliterated. When the back is sufficiently arched, the head and legs, by their weight, exert a little traction.

In order to bathe the back or change the clothes, the child on its frame is laid, face downward, on a large pillow, the under side of which is built up so as to maintain the extended position while the frame is removed. Some prefer to have two frames using each on alternate days. The outer garments include both frame and child.

*The Plaster Bed.*—The method of making the plaster bed is described in Chapter XX, page 336. The patient is secured by bandaging the trunk to the plaster bed, sometimes the forehead as well. In

high dorsal and cervical disease, Lorenz uses the jury mast incorporated into the plaster for traction. At the first daily bath, the back should be examined for areas reddened by pressure, and the padding should be correspondingly altered. Daily removal and reapplication of the plaster shell is done in the same way as with the Whitman frame. Since a child in a plaster bed is easy to carry about, he should have abundance of fresh air out of doors, plenty of nourishing food must be given, and freedom to kick his legs about will add much to his comfort and appetite. When the home

FIG. 115.—The plaster bed with head traction for cervical caries. (*Children's Hospital.*)

is such that the plaster bed cannot be used intelligently, the plaster jacket with or without head piece is a good substitute for the recumbent treatment. (See Chapter XX, page 334.)

The plaster bed is much used in Europe. Hoffa believes that the only efficient fixation of the diseased column is obtained when the patient lies on his back with the whole spine in hyperextension and stays so until the diseased spine consolidates. He prefers the plaster bed because the patient can be easily carried about out of doors, and can, therefore, receive better general treatment. He continues the recumbency until every vestige of tenderness and spasm is absent from the back and the child can stand and walk with unrestrained attitude and movements. He considers it better to keep the patient lying down too long than too short a time.

**Ambulatory Treatment.**—This form of treatment certainly dates back several centuries. Ambroise Paré has a chapter on "amending the deformity of such as are crooked backed." He had them wear "breast-plates of iron full of holes all over them, whereby they may be lighter, and they must be so lined with bombast that they hurt no place of the body. These plates will do them small good who have attained their full growth." He does not claim this as his own invention for many mechanicians had world-wide reputations for cures they effected.

FIG. 116.—Shows the pressure mark of an efficient brace applied for lumbar caries.

The steel brace is an efficient means of treatment for lumbar and cervical cases throughout the disease, unless some special indication arises which demands recumbency. Its efficiency is less in the dorsal region because here the spine is already curved in the direction the disease bends it. For a description of the brace and its various modifications, see Chapter XXI, page 350.

For cervical disease, cervico-dorsal disease and those cases of high dorsal disease in which ambulatory treatment has to be resorted to, certain modifications have to be added to the brace and jacket to support the head. (See Chapter XXI, page 353.)

These are the Thomas collar (p. 357), the Taylor ring head support (p. 353), the wire chin rest, (p. 354), and Goldthwait's head support (p. 355). Instead of steel braces, the plaster-of-Paris jacket of Sayre has been used by many surgeons since 1874 and it is still preferred by many to any other form of ambulatory treatment. It was employed with forcible correction by Calot and Chipault, in France, twelve years ago, but this procedure has been abandoned. The several methods of applying plaster jackets in the recumbent position, will be found in Chapter XX, pages 333–340.

Beely, Schede, Wullstein, Hoffa, R. T. Taylor, and others, use strong traction combined with pressure from levers and screw pads to correct the deformity during the application of jackets. In reality, they are using in a modified and milder form, Calot's forcible correction, only without anæsthesia.

## TREATMENT OF COMPLICATIONS.

**Paralysis.**—Adolescents and adults are often cured of attacks of paraplegia by the application of a plaster jacket in the corrected position of the spine. In the child, this improvement is less frequent. This may be due to greater difficulty in maintaining overcorrection during the application and setting of a jacket because the back is so short. For the child, overcorrection on the Whitman frame, combined with traction on the head and legs is more efficient. One must remember that paraplegias recur. Traction on the head and feet may also be made on the bed frame of Bradford or the plaster bed. It has occasionally been observed that the draining of abscesses causes immediate disappearance of paralysis. During the paralysis, electricity, massage, and passive gymnastics should be used daily.

*Laminectomy.*—The operation of laminectomy for the relief of paralysis in Pott's disease, has been attempted at times since 1882; costo-transversectomy of Ménard has also been used; neither are free from danger; a mortality of 50 percent has occurred in laminectomy operations and on account of the large mortality and the comparatively few good results obtained, many advise against these operations for paralysis. It is also difficult to know when they should

be done, for we are told by some that the operation is not to be undertaken too soon after the onset of paralysis, because the paralysis might get well of itself; others tell us that it is not to be done too late for it is useless if the pressure paralysis of the cord has produced an incurable lesion.

The operation of laminectomy is, therefore, chiefly done for the relief of pressure from the fragments of a fracture of the spine, or to give access to the cord for the removal of a tumor. In deciding upon the operation, one should remember the high mortality, that many of those who survive are not improved, for one cannot estimate beforehand whether the amount of damage already done to the cord substance will or will not admit of repair.

Murphy, of Chicago, opens the spinal canal by a simple longitudinal incision down the sides of the spinous processes; on either side a blunt dissection of the laminæ is carried as far as the transverse processes; then he punctures the laminæ with a special conical drill and cuts them with a *rongeur*, and a bone cutting forceps of special design, on both the right and left sides of the column. He removes the laminæ and spinous precesses of three or four vertebræ, gently displacing the cord to one side; and if he exposes granulomatous tissue on the posterior surface of a vertebral body, he curettes it and fills the cavity with a plug of Moorhof's filling for bones. The wound is closed without drainage. From six months to two years may be required to get well of paralysis where sequestra have been removed from the spinal canal or an abscess in the spinal canal has been drained. Scars have sometimes re-opened after healing and subsequently closed again.

**Abscess.**—Treatment for cold abscesses in Pott's disease is still *sub judice.* In the pre-antiseptic days, the let-alone policy prevailed; with the coming of aseptic surgery, came also free drainage and curettage of diseased vertebræ and of abscess cavities; then less radical means were advocated. Aspiration combined with the injection of iodoform emulsion is in favor in many parts of Europe and in some places in this country. Most surgeons follow a middle course; they immediately drain all abscesses which threaten life,—like the retro-pharyngeal or mediastinal, those with high fever and great

prostration, those which persist many months without diminishing, and those ready to break externally. A retro-pharyngeal abscess may be opened in the throat and sometimes in the side of the neck. In opening one of these in a baby's throat, it is well to have him held in the lap of an assistant in front of the surgeon; the mouth is held wide open with a gag, while the surgeon with one finger feels the bulging fluctuating posterior pharyngeal wall and quickly guides the tip of a guarded knife to open the cavity. The patient must be immediately inverted to prevent his sucking pus into the larynx. A mediastinal abscess is reached by resecting the transverse process and the rib attached to it, then by doing a deep dissection along the pedicle and the side of the body of the vertebra subperiosteally with a long blunt pointed periosteal elevator, all the important structures are avoided.

A boy is now at the Convalescent Home who underwent this operation. He has a very small knuckle at the fifth dorsal spine and is in excellent health. The wound through which his mediastinal abscess discharged has been closed for two years. Abscesses of the posterior mediastinal space, like the retro-pharyngeal, endanger life and demand instant relief. The other spinal abscesses are less urgent.

The timidity of surgeons today is often in marked contrast to the boldness which characterized the draining of extensive cold abscesses in Pott's disease several years ago.

## SACRO-ILIAC DISEASE.

This affection is never very common but in children it is rare. It is also called sacro-coxitis, sacrarthrocace and sacro-coxalgie. It is rather more common in men than in women. It is generally a tuberculous infection of the bone but other organisms may cause typical symptoms of the disease. Traumatism and strain frequently cause it; it has been attributed to the strain of parturition. In children the bone infection is more acute than in adults; there is greater tendency to necrosis.

In 1890, Van Horn knew of only 6 children under ten years of age, out of 72 cases of sacro-iliac disease.

The differential diagnosis between sacro-iliac disease and tuber-

culous disease of the last lumbar vertebra and of the sacrum is extremely difficult because the process almost always begins as an acute bone inflammation on one side or the other of the sacro-iliac joint. In children, the pain is apt to be very acute, and is referred to the middle of the back, the side of the pelvis, the buttock, or the

FIG. 117.—Sacro-iliac disease with a sequestrum in the ilium. (*Children's Hospital, A. W. George, Radiagrapher.*)

thigh. Certain movements, like sudden coughing and laughing, bring sudden twinges of pain. In standing the body usually inclines toward the sound limb. Lying down relieves the pain and removes the peculiar feeling of insecurity and weakness. Tenderness over the joint is usually elicited by pressure and the finger often detects

swelling and thickening. If the disease has lasted long enough, sudden, lateral compression of the iliac crests a manipulation which slightly moves the joint, is painful. Abscess formation is the rule. The pus routes may be a simple superficial pointing over the crest of the ilium near the posterior superior spine, or it may burrow through the sciatic notch and appear in the ischio-rectal fossa, or break into the rectum, or cause an accumulation under the fascia covering the iliacus muscle and point in the groin, like an abscess of the ilio-psoas in Pott's disease.

Four conditions may be mistaken for it, lumbago, sciatica, hip disease, or Pott's disease. A positive diagnosis is sometimes only reached after watching the case for some time; but tenderness over the sacro-iliac joint and pain on compressing the wings of the innominate bones are very significant. The affection is extremely chronic; many of the children have with it extensive necrosis, prolonged suppuration, and die of exhaustion.

**Treatment.**—In view of this, treatment guided by the radiograph, should be directed to early removal of the focus of inflammation in the bone, or at least, opening up the cortical bone and drilling through into its interior as is done for early osteomyelitis. Abscesses should be drained early by small incisions; excision of the sacro iliac synchondrosis may be reserved for severe cases.

General treatment should be directed to upbuilding the general health by a generous nutritious diet and by living out of doors. The new treatment, the subcutaneous injection of an emulsion of a sterilized culture prepared according to the method of Wright from a culture of the organisms found to exist in abscess, offers a new method of attack and should be given a trial for chronic sinuses.

In the case of a boy of 4 who had had an ischiorectal abscess discharging for two years, the writer found an abscess in gross appearance like a large hydronephrosis or a cystic kidney. Upon incising the abscess, three sequestra were discovered on the iliac side of the synchondrosis and considerable softened, carious bone was curetted away from both ilium and sacrum. The abscess wall showed many giant cells in a tissue resembling granulation tissue; several giant cells contained tubercle bacilli and cover glass smears of pus showed

tubercle bacilli. The boy improved considerably but a sinus persisted and he died about a year after the operation, of pneumonia.

All children are not as badly off. Prof. L. A. Sayre, of New York, reported the case of a child, 2½ years old, who fell behind a trunk, and later developed a lumbar abscess which was drained three times but always refilled. Dr. Sayre removed a sequestrum from the joint and the patient grew to be a strong man, dying of an accident at the age of 32.

## CHAPTER XV.

# TUBERCULOSIS OF BONES AND JOINTS (CONCLUDED).

## HIP DISEASE.

Hip disease, is known as hip-joint disease; morbus coxarius; morbus coxæ, chronic articular ostitis of the hip; coxitis; German, Hüftgelenksentzündung; French coxa tuberculose; coxalgie; coxarthrocace; Italian, malocoxario; coxite; coxotuberculosi; Spanish, coxotuberculosis.

Hip disease, though a distinct and well-defined process in the human body with well-studied symptoms and signs, is nevertheless a disease in which errors of diagnosis are often made, for it is easy to overlook it and it is also easy to misinterpret other conditions which resemble it in its early stages especially. While it affects both children and adults, the great majority of cases originate before the age of ten years. Almost the commonest of the bone-tuberculoses, it is more frequent in the right than in the left hip, and occurs twice as often in boys as in girls; it is decidedly uncommon in both hips (double hip disease), but it is often observed accompanying tuberculosis of other joints. In New England it is a little less common than Pott's disease but of more frequent occurrence than all the other forms of joint tuberculosis, for at the Children's Hospital in Boston in the forty-seven years of its existence there have been under observation and treatment 2,502 patients with hip disease, 359 with Pott's disease, 427 with tuberculosis of knee, 416 of the ankle; and there were fewer in the other joints.

**Pathological Anatomy.**—The pathology of hip disease differs but little from that of tuberculous ostitis in other joints, and in most cases the primary focus of disease is found in the head of the femur, near the epiphyseal cartilage or the articular cartilage. When the focus of disease reaches the surface, tuberculous pus per-

forates the joint, the cartilage becomes thinned, in spots yellow, and ulcerated and the surface of the bone worm-eaten. This filling of the joint with tuberculous pus may produce a pathological dislocation, but this is very rare, although a partial destruction of the femoral head, migration of the acetabulum and a distorted position of the limb may simulate a dislocation.

FIG. 118.—Right hip disease with abscess in a child with coxa valga. Note the indistinct outline of affected joint, small bone and thin cortex of femur. The right side of pelvis is small. (*Children's Hospital, A. W. George, Radiographer.*)

The shaft of the femur undergoes rapid atrophy beginning with the onset of disease and it is demonstrable by X-ray. Owing to the destructive ostitis, and atrophy, the neck of the femur may spontaneously fracture or the epiphysis separate and surgeons have often had to remove the loose head of the bone. Sometimes the whole articular cartilage is lifted from the bone by granulations; sometimes the head of the femur disappears altogether.

The acetabulum may be perforated by destructive ostitis. Inside of the pelvis a dense wall of fibrous tissue forms with pus between it and the bone, the swelling may be felt through the rectum. More often the disease causes a weakening of the upper part of the acetabulum for the muscles and the body-weight drive the femur upward producing destruction and eventually an enlargement here and a migration of the acetabulum upward. This migration is one cause of short leg which is usually overlooked.

FIG. 119.—Healed hip disease with ankylosis in abduction in an adult. (*A. W. George, Radiographer.*)

Disease may spread in the pelvis beyond the limits of the acetabulum. Abscesses in time frequently become superficial, for the pus from the bone or joint burrows or the disease spreads to the peri-articular tissues, or separate foci of disease may develop in the bursæ or soft parts around the joint. Pus may get inside the pelvis from disease of the femur, spreading through the bursa

between the hip and the psoas muscle into the iliac fossa and gravitating to a point on the interior opposite the acetabulum. In time nature may absorb or calcify this tuberculous debris or it may be discharged into the rectum or bladder, or externally.

Malpositions, shortening of the leg, and impairment of the general health, characterize advanced cases. After recovery, which is often with ankylosis and malposition, the autopsy of a healed case reveals cheesy foci which are still active, though encapsulated. These are the cause of late relapses of the disease and of the fresh inflammation after forcible manipulations to correct deformity.

FIG. 120.—Right hip disease with shortening. (*Children's Hospital.*)

**Clinical History.**—The onset is generally insidious. Lameness there is with remissions and often night-cries, crying out in the sleep, but the onset may come abruptly and suggest trauma.

*Stiffness.*—A stiff gait in the morning and after sitting for awhile is an early symptom. The limp is generally less at night than in the morning and the walking child avoids having weight long on the affected limb. The knee of the affected side, in standing, is often slightly bent, the pelvis tips down, and the thigh is slightly abducted, as may be seen by the deviation of the fold between the buttocks from the median line.

*Lameness*, but little noticed at first, is usually well marked within a month of the onset. Walking is not painful except in a few severe cases. Malpostures of the hip give rise to a variety of peculiar attitudes and gaits.

*Pain*, if present, is usually referred to the knee, and the front of the thigh. As it progresses, stiffness increases, malpostures add to the increasing lameness and disability, and there may be exquisite

pain and tenderness in the thigh and knee. Still later, abscesses form and the general health is impaired. Pain and sensitiveness may be absent throughout the course of the disease. Few cases have any pain in the hip-joint. In the acute period, pressure over the trochanter or over the anterior surface of the joint may cause complaint.

*Self-protection.*—The child in bed is often observed to place the foot of the well limb under the lower part of the other leg and so unconsciously protects the hip from moving, or with the toes of the well foot pressing on the dorsum of the other, exerts traction.

*Sensitive Joint.*—There is often great variation in the amount of joint sensitiveness present, and the hip movements are restricted by muscular spasm to a varying degree, which however has nothing to do with joint tenderness. At times very sensitive joints may be flexed, extended, abducted and adducted with comparative freedom, provided that it be done very slowly and the child's confidence secured. Only rapid movements cause pain, crying, and fixation; on the other hand, a child whose hips are rigidly fixed by spasm will often have no pain. The clinical significance of this is not known.

*Spasm Restricting Motion.*—When the limit of motion in a given direction is reached, muscular spasm stops it. Normal movements may be slightly or much restricted by it.

*Night cries* are present sooner or later in children with hip disease. As the child drops to sleep, the muscles which fixed the hip in a painless position gradually relax and as the hip-joint moves in consequence, the child awakes with a startled cry and does not know what hurt him. Night-cries are typical of most forms of chronic tuberculous joint disease, and are most frequent in disease of the hip and knee.

*Atrophy.*—When the child is stripped for examination, the surgeon immediately notes wasting of the muscles of the affected limb, often with slight shortening, for muscular atrophy, bone atrophy, and true shortening are usually present early. Their cause in unknown; though many theories have been advanced about it, recent experiments on rabbits, by A. T. Legg, point to its coming

from disuse. Bone atrophy is easily recognized in radiographs and is present not only in the whole of the femur but also in the other bones of the leg. Bone atrophy is characterized by diminished resistance to the passage of the X-rays so that, in developing the plate, the bone shadow begins to clear up and show details of structure while the shadows of tendons are still visible on the negative. The

FIG. 121.—Cured hip disease with shortening. Method of determining height of high sole.

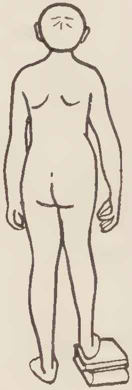

FIG. 122.—Hip disease with shortening, shows the atrophy of muscles of thigh and leg.

FIG. 123. Double hip disease with flexion deformity. (*Children's Hospital.*)

cortical bone of the femur is noticeably thinner than its fellow and is sharply penciled. The examination of the patient should, therefore, include a radiograph of the affected hip.

**Physical Examination.**—While the child walks about stripped from waist down attitudes and gait are carefully studied, special attention is given to detect hip-flexion and restricted movements. These are then tested by certain measurements with the patient lying on a folded blanket on a table, and a record is made of

the amount of permanent malposition, of the joint motions, and of atrophy and shortening. To detect slight degrees of fixed hip-flexion the surgeon grasps the well leg below the knee, flexing the knee upon the body to the limit of motion. This manœuvre, devised by Thomas, brings the sacrum flat on the table and, if there be permanent flexion of the hip, the knee on the affected side rises to show the amount of permanent hip-flexion. To test permanent adduction or abduction one makes a line connecting the anterior superior spines perpendicular to the axis of the trunk when the difference in direction between the axes of trunk and limb shows it. By these two manœuvres, the permanent flexion of the hip, and the permanent abduction or adduction deformity of the suspected hip are recognized and the amount is easily estimated in degrees after a little practice.

FIG. 124.—Hip disease healed with a half-inch shortening and almost perfect motion. Unusual result. (*House of Good Samaritan.*)

*Shortening.*—The length of the leg from the anterior superior spines to the internal malleoli is then recorded (showing actual shortening), and the circumferences of the two thighs at the perineum are compared and the calves at their largest diameters to show atrophy.

*Hip Motion.*—There remains the estimation of the amount of joint motion. Grasping with one hand the pelvis by placing the fingers on the ilium and sacrum and the thumb on the anterior superior spine, the surgeon with his other hand gently, slowly flexes the knee until a position is reached where the commencing, pelvic tipping shows that further motion is prevented by spasm. This point is the limit of motion in flexion and the number of degrees traversed by the thigh represents the amount of flexion allowed by the hip. Abduction and adduction are estimated by a similar test

of lateral movements. The legs are then straightened and the surgeon gently rolls the thigh as far inward and outward as spasm allows, making a record of the amount of inward and outward rotation permitted in the joint. Then with the child on his face, hyperextension of the hip is easily estimated by grasping the ankle, flexing the knee and lifting. The normal amount of hyperextension is about 30°.

The physical examination is completed by feeling the two trochanters to detect enlargement, and by deep palpation to explore the iliac fossa and all the soft parts about the hip; brawny thickening and the presence of enlarged lymph nodes are often noted, the former arouses suspicion of abscess. The physical examination should include a radiograph, and a record of the temperature and pulse and the general nutrition of the patient should be noted.

The diagnosis of hip disease is based upon a history of gradual onset of lameness with remissions, usually following trauma, the kind of lameness, night-cries, restricted motion, the muscle and bone atrophy, shortening of the limb, or, in a few early cases, lengthening, and the slight elevation of temperature, which exists in all tuberculous bone disease of the joints. Rigid adherence to these diagnostic points will prevent the mistake of including many non-tuberculous conditions which simulate hip disease.

**Differential Diagnosis.**—Among the conditions to be excluded are the following: strains of the muscles of the thigh, and enlarged glands of the groin from any cause, which may produce persistent flexion and pain on moving the thigh. Growing pains always arouse a suspicion of hip disease, and usually repeated examinations should be made to eliminate it. Contusions of the joint or traumatic synovitis may simulate hip disease very closely and the diagnosis is often erroneously made, only to be corrected by the rapid and permanent subsidence of symptoms. The joint infection usually called rheumatic fever, if confined to one hip of a child, simulates hip disease, but the fever is usually high, joint sensitiveness extreme, and cases often pass through a polyarthritis in which joints are successively invaded. Acute arthritis or epiphysitis of the hip-joint of infants is a far more acute process, with high fever, great constitutional dis-

turbance, local heat, and swelling, indicating rapid abscess formation. Hip disease should never begin so acutely.

Infectious arthritis after scarlet fever, diphtheria, pneumonia, typhoid fever, and other diseases is more apt to simulate the so-called rheumatic fever. If the infection be really a true osteomyelitis it should be recognized by radiographs. Gonorrhœal arthritis closely resembles hip disease in the adult, but the onset is usually very sudden and acute. Extra-articular hip disease, that is tuberculous disease in the shaft, neck, or trochanter, may cause limping and pain with very little limitation from muscular spasm, and slight continual elevation of temperature. A radiograph offers for these cases the most accurate means of diagnosis.

Arthritis deformans may pass for tuberculous disease in the adult. A careful physical examination of the rest of the body, will in most cases, give evidence of a general arthritic affection. In childhood, the temperature is usually not raised, although a slight elevation of temperature and an increase of pulse may be observed in the beginning. The type in children is called Still's disease, is polyarticular and usually painless.

Hip disease may also be confounded with certain conditions not in the hip-joint. For instance, the early stages of lumbar caries of the spine may simulate hip disease before the appearance of deformity because referred pains from lumbar disease may be confined to one leg or even to the sensory part of the anterior crural nerve, and unilateral psoas contraction flexes the hip and may produce a limp very like hip disease. In exceptional cases, disease in the sacral or lumbo-sacral region in young children gives rise to spasm of the muscles about one hip, but repeated careful examinations will usually show the true seat of disease. Disease of the sacro-iliac joint is rare in childhood and is more often mistaken for lumbar caries than for hip disease. Careful observation of the muscles involved in the spasm, of the restricted movements of the hip and of the spine, and the atrophy and shortening of the leg, aid in discriminating hip disease from sacro-iliac.

Inflammation of the bursæ around the hip gives rise to swelling, tenderness, limitation of motion in certain directions, but extensive

muscular spasm like that of hip disease is usually absent. It is sometimes, however, difficult to diagnose a hip disease which accompanies bursitis.

Knee-joint disease, tumor albus, is misleading only because the pain in hip disease is referred to the region of the knee, usually to the inner side. Careful physical examination should guide us to a correct diagnosis.

Coxa vara produces shortening and limping. The trochanter is above Néltaon's line, but the hip motion is limited only in abduction. Radiographic confirmation of this diagnosis should be made.

FIG. 125. Hip disease in adult healed in poor position of adduction.

Congenital dislocation of the hip-joint is so dissimilar that it is sufficient to mention the possibility of confusion from this source. Careful physical examination and the radiograph should always lead to a correct estimation of that condition. Infantile paralysis during the acute stage of onset may exhibit marked pain, tenderness, and immobility of one or both legs, with fever and vomiting, but it lasts only for a couple of days and is superseded by loss of power, coldness, and rapid atrophy. Hysterical joint disease may resemble hip disease and require several painstaking examinations. As a rule, the prominent symptoms are atypical and variable, and are not consistent with one another. The radiograph and temperature chart are here of great value. Fracture of the neck of the femur in children is often a greenstick fracture, a traumatic coxa vara. Patients may walk a day or two after the accident with limping and discomfort. Muscular spasm is often present. The history of a fall of ten feet or more, the immediate disability, the shortening, the elevation of the trochanter, and the X-ray should establish the diagnosis.

**Prognosis.**—The mortality of hip disease is greatly influenced by the care the patients receive. Cases in private practice do better than hospital cases; those under prolonged treatment in sanatoria better than those who come as out-patients from unhygienic homes.

In private practice the mortality is usually two or three percent. At Berck-sur-Mer, the great seaside sanatorium for Parisians with tuberculous bone disease it was twelve and one-half percent. The mortality of hip disease has been figured as high as twenty-five or thirty percent. The causes of death are phthisis, tuberculous meningitis, acute miliary or general tuberculosis, prolonged suppuration with amyloid degeneration, exhaustion, intercurrent diseases and septicemia.

## TREATMENT OF HIP DISEASE.

**Treatment.**—The importance of general constitutional treatment in hip disease as well as in all tuberculous affections has been emphasized most strongly during the past few years. There has been a tremendous increase in the number of sanatoria dotted over the whole sea-coast of Europe. European physicians prefer the close proximity of the sea for non-pulmonary tuberculosis and high altitudes for pulmonary patients. In this country much less stress has been laid on seashore treatment, aithough a sanatorium for all the year round treatment has been established at Manhattan Beach and a number of seaside sanatoria are open during the summer months Open air, day and night, with proper restrictions, and allowance for weather; an abundance of nourishing food, and the restriction of exercise to a point which should never cause fatigue, should be insisted upon.

Local treatment is, however, of great importance, and will be needed for, at least, two or three years, even if begun early, and joint protection for two or three years more, for the danger of relapse is great and often follows a too early discontinuance of treatment. Should acute symptoms not recur, flexion and stiffness may, and some shortening always, is expected. Distortions, however, should not be permanent and usually represent inefficient local care. Atrophy is never entirely cured but strong muscles are the rule. An abscess increases the danger to life but not the chance of subsequent deformity.

Two methods of orthopedic treatment have for many years advanced rival claims in curing hip disease, the school of fixation, and

the school of traction. An ideal treatment should combine both. Of recent years, Lorenz, of Vienna, has stoutly maintained that weight-bearing on the affected hip is to be encouraged, that hip disease is best cured by ankylosis with shortening in a position favorable for walking, and he advocates the use of a short plaster spica bandage and free use of the leg in walking, except when acute symptoms come on, believing that in the end the shortening will be no greater although the trochanter may be elevated and the femoral neck depressed, because free functional use of the limb will increase bone growth

FIG. 126.—Ordinary and lateral traction for hip disease applied to relieve persistent night-cries and sensitiveness.

which is retarded by disuse in splints. During acute exacerbations recumbency is resorted to. It is an open question which of these methods have most abscesses.

**Recumbency.**—During the acute period of hip disease, recumbency on the bed frame with traction prevents moving the joint and, if the weight be sufficient, stops muscular spasm. The pulley may be arranged as shown in the accompanying figure (Fig. 127) so that it pulls upon the diseased leg on the line in which it is held when the pelvis is square on the bed frame. If flexion is present, the pulley

is elevated, if abduction or adduction, the leg is pulled more in or out. The amount of weight varies with every case; but it should be as much as can be borne without discomfort. The foot of the bed should be raised to furnish counter-traction. In using the bed-pan the frame should be raised and all movement of the hip avoided. Persistent night-cries and persistent sensitiveness of the hip call for lateral traction as well (see Fig. 126). Once a day the back should be washed with alcohol and powdered and the nurse should then use

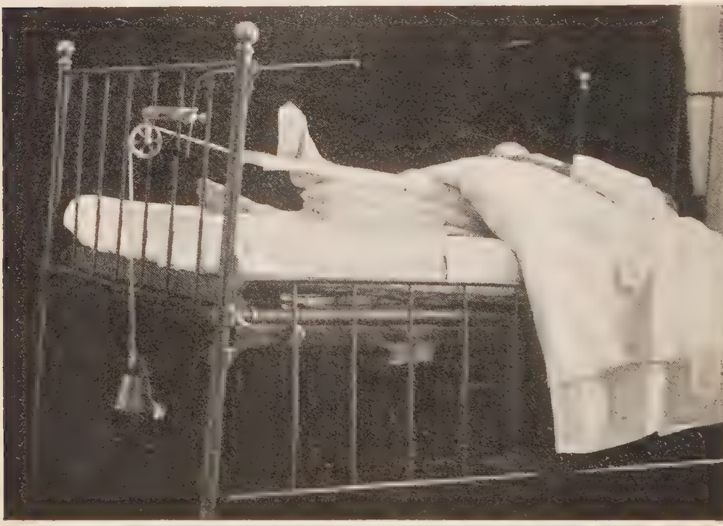

FIG. 127.—Traction in bed at the Children's Hospital; the leg elevated to accommodate slight permanent flexion of hip.

great care that the hip-joint be not moved. Traction on the bed frame may be made on a go-cart, for the general treatment must not suffer during this period.

**Ambulatory Treatment.**—When acute symptoms subside, ambulatory treatment is in order. This should be given tentatively. The patient should get up for a short time mornings and afternoons, and should sleep wearing a splint instead of the weight and pulley.

*Traction Splints.*—The original traction splint was devised by Dr. Henry G. Davis, of Chelsea, Mass. Many modifications of this splint are in use today. For a description of splints for hip disease see Chapter XXI, page 364. Fig. 126 illustrates a method of applying adhesive plaster traction straps for use in bed or with these splints. Perineal straps are made of webbing covered with canton flannel or, in the case of small children where constant wetting cannot be avoided, the webbing may be passed through a piece of rubber tubing the size of the little finger. Properly applied extension in a splint demands constant care of the perineum to prevent chafing and excoriations. Alcohol and powdered talcum must be freely used.

*Fixation.*—In acute cases or in acute exacerbations efficient fixation is needed without traction. A plaster bandage from the toes to the axillæ gives rest to the joint, and the long double spica, of course, prevents locomotion. It has been claimed that immobilization produces ankylosis. Fixation of a healthy joint even for prolonged periods does not do so. Fixation for ambulatory treatment may also be obtained by the Thomas hip splint. (See chapter XXI, page 369.)

*Convalescent Splints.*—Local treatment should be continued during the stage of convalescence, that is when muscular spasm can no longer be elicited. The hip is then sufficiently cicatrized to resist slight injury, but the frequent impact of the body-weight in walking might cause an acute exacerbation by lighting up a quiescent focus. The child may be told to swing the leg free from the ground, using crutches; or the traction splint may be provided at its lower end with a rubber crutch tip or a jointed socket to fit the boot. The length of the splint should be so regulated that the heel stays an inch off the ground to allow the child to walk upon the toes only. The high sole is no longer needed now but an ordinary boot is worn on the well foot.

*Length of Treatment.*—Hip disease requires so long for its development that we must expect it to be a good while in going. It is safer to continue protective treatment and the convalescent splint until a long time has been given the joint in which to recover itself.

Those apparently cured in childhood with a fixed joint or slight hip motion may suffer from painful acute attacks later in life.

*Osteotomy.*—When, however, hip deformity persists permanently and causes lameness, correction is necessary. The choice of a method of correction will depend upon the state of the hip-joint. If true ankylosis be present, osteotomy below the trochanter minor is demanded. If, however, a slight degree of motion be permitted in a hip-joint fixed by fibrous adhesions, manipulative correction under anæsthesia or correction by recumbency and traction are

FIG. 128.—Left hip disease with abduction.

FIG. 129.—Adduction deformity in right hip disease.

to be preferred. Should osteotomy successfully correct deformity in a hip which is not ankylosed, subsequent distortion may vitiate the result. Osteotomy performed below the lesser trochanter is known as Gant's operation.

The patient, anæsthetized, lies on the side with a sand pillow between the legs, and the skin of the field of operation is sterilized carefully. The chisel is driven in an inch to an inch and three-quarters below the great trochanter, with the blade in the long axis of the limb. When it engages the bone it is turned so that the edge is at right angles

to the axis of the limb. The osteotome is then driven into the bone by sharp blows of the mallet, turning the cutting edge first forward and then backward, so as to cut obliquely through three-quarters of the entire cortex of the shaft. Lateral motions between each blow prevent the osteotome from becoming wedged. It is better not to divide the bone completely. Very little force is needed to complete the fracture of the bone, but if the femur does not readily yield, the chisel should again be driven in still farther, loosening it after each blow of the mallet, and directing the blade in a new direction. If necessary, bands of contracted fascia which prevent full extension and abduction may be divided. A small dressing of sterilized gauze is applied and the entire limb fixed in a carefully applied spica bandage extending to the axilla, padding the anterior spine, the iliac crest, patella, and spinous processes of the vertebræ to prevent sloughing.

The position in the spica bandage should be one of slight abduction, the shorter the leg, the more abducted it should be. Hemorrhage is rare. Six weeks in bed and six weeks up in a plaster bandage is the rule. Cases under sixteen years of age are apt to relapse after osteotomy, as they are more prone to fibrous than to true joint ankylosis.

## DOUBLE HIP DISEASE.

Double hip disease is at best very disabling. During the acute stage recumbency and efficient traction followed by hip splints is the usual treatment here. During the painless stage a double Thomas hip splint makes it easy to carry the patient about. Fixation in plaster may also be employed, or locomotion may be permitted with double traction splints and crutches. Probably recumbency offers the best chance. Combined with the go-cart and open air treatment it may be used for long periods of time without injuring the general health. Hip disease in combination with caries of the spine is both disabling and exhausting.

## ABSCESS OF HIP DISEASE.

At the present time abscess occurs in about 30 percent of all cases of hip disease.

As already noted in the abscesses of Pott's disease, surgeons vary and fashions vary in treatment. The abscess of hip disease may be let alone, aspirated, drained by small or large incisions, the drainage may be combined with swabbing with chemicals, like pure carbolic acid, alcohol, iodine, etc., or with free curetting of the abscess walls.

The tendency of many surgeons today is to open by small incisions without disturbing the interior, whether the abscesses are caused by liquefaction of old tuberculous detritus, or by tubercle and pyogenic organisms. J. S. Stone has used this method with good results in hip abscesses, but the choice of treatment must be made in each case separately.

FIG. 130.—Hip disease abscess.

By other surgeons small circumscribed abscesses are incised freely, swabbed with carbolic acid, then with alcohol or with a $2\frac{1}{2}$ percent solution of formalin and the wound tightly closed by sutures, leaving a small drain to be removed in forty-eight hours. Such cases have healed by first intention and healed permanently, but the majority develop a fistula later. Free incision and curetting is now less employed than it was, because extensive channels are opened for absorption from necrotic tissues left after curetting and for fear that the dressing, cannot be kept free from infection much longer than two weeks.

The writer has little experience with aspiration of hip abscesses. In a few cases where he has employed it, the abscesses refilled later.

**Early Removal of Isolated Foci of Infection.**—With the study of hip cases by means of the X-ray, this abortive treatment at once sprung into vogue. Starr, of Toronto, used it successfully on the knee. R. T. Taylor, of Baltimore, employed it enthusiastically for hip disease but later abandoned it. Other surgeons have had good results after the removal of foci in the vicinity of the great trochanter. Painter says that occasionally we become enthusiastic over our attempts to extirpate tuberculous foci in childhood. The

main objection to it is the unlikelihood of wholly extirpating the disease. He believes in the operation for adults undergoing a relapse, as he considers that there is much less likelihood then of disseminating tuberculosis and of infection. Adolescents may be considered in this same light.

Huntington, of San Francisco, devised the following operation in 1905: He opens the shaft of the femur with a half-inch trephine at the lower border of the great trochanter, tunnels through this opening, with a large curette, removing from the neck of the femur most of its cancellous interior till at a depth of two or two and a half inches the epiphyseal cartilage is encountered. It is generally desirable not to interfere with this, but if it be necessary to enter the head of the bone beyond, either at the time of operation or for the drainage of tuberculous foci in the femoral head and neck subsequently, a small curette should be used. This route had already been employed by Macnamara, of Dublin. The bone cavity should be packed with gauze. This is the most direct route for the removal of foci near the femoral head. Huntington recommends it both for osteomyelitis and for tuberculous disease.

## EXCISION OF THE HIP.

A radiograph carefully studied in connection with the symptoms and signs should give us the best indication for excision of the hip, but skill and experience are necessary both to obtain satisfactory X-rays of this joint and to interpret them correctly. In England and Germany excision of the hip has been used to a far greater extent than in this country.

Bardenheuer excised the acetabulum in twenty-six patients. The operation is a severe, not a fatal one, but it has not been done much in America. He considers it indicated in all cases of septic involvement of the acetabulum and acetabular caries where conservative treatment has failed. His incision extends along the whole length of the crest of the ilium. All muscular attachments are cleared as far as the acetabulum. With a Gigli saw the acetabulum is separated from the ramus of the pubes, from its connection with the ilium, and the descending ramus of the ischium. It is easier to remove

the acetabulum without opening the joint. If the head of the femur is also diseased it is sawed off at the neck. The wound should be closed with sutures and traction applied to the limb which is placed in an abducted position. As mutilation is great, a less useful limb may be expected than after simple excision of the head of the femur.

Excision of the hip is performed through a curved incision over the trochanter from four to six inches long, commencing at a point midway between the anterior superior spine and the trochanter, exposing the trochanter and curving forward below it. As the incision, deepened by careful dissection exposes the capsule and the trochanter, the tendons of the three glutei are divided, and the muscles lying in the line of incision are retracted, so that the capsule may be widely opened and the head turned out, the limb being flexed and rotated outward for this purpose. The head is sawed off with part of the neck. The muscular attachments to the posterior surface of the trochanter are then exposed by rotating the limb inward and the trochanter, if diseased, is sawed off. The neck is replaced in the acetabulum, the wound is partly sutured with drainage, the usual large aseptic gauze dressings are applied and a plaster bandage or Thomas hip splint used with traction in bed. During convalescence a traction hip splint with slight abduction is needed for many months.

During the operation the acetabulum should be examined, any sequestra removed and the carious surface curetted. If perforated, rough edges of the bone are removed freely. It is practically impossible to remove all the tubercular tissue in this operation. The ultimate mortality from this operation at the Children's Hospital, Boston, and the Hospital for Ruptured and Crippled Children, in New York, is about 46 percent, the immediate fatality 7 percent. Rapid general miliary tuberculosis has been found in over ten percent. Excision of the hip is reserved for those cases in which mechanical treatment fails and where removal of extensive sequestra is necessary. It is a life saving measure. Useful limbs are secured, although the shortening is considerable, and the mechanical conditions are not conducive to the formation of a firm joint. In successful cases

a new joint is established and the neck of the bone becomes firmly attached to the ilium. A series of cases at the Children's Hospital four or more years after excision all walked without cane or crutch.

Amputation should be a very last resort. Extensive amyloid degeneration or a moribund condition contra-indicates it. The mortality is slightly higher than in other amputations of the thigh.

## CHAPTER XVI.

# TUBERCULOSIS OF KNEE, ANKLE, TARSUS, SHOULDER, ELBOW, WRIST.

## TUMOR ALBUS.

Tuberculous disease of the knee-joint; white swelling of the knee, tumor albus; Scrofulöses Caries; Tuberculöses Caries; Tuberculose chronique du genou; Tuberculose articulaire, etc.

In considering hip disease and spinal disease we confessed the inability always to recognize tuberculous disease and to differentiate it from other chronic affections. Practically all chronic inflammations of the knee, however, which have typical symptoms and the course of a tumor albus, are considered tuberculous.

White swelling of the knee is next in frequency and importance to hip disease. It interferes for a long time with locomotion and often results in permanent lameness; yet the prognosis is less serious both as to life and function of limb. The mechanical protection required to prevent deformity is a less difficult problem.

**Pathological Anatomy.**—The disease is said to develop from a tuberculous infection either of the synovial membrane or of any of the bones forming the joint. Pathological evidence gathered here shows that a primary synovial involvement must be very rare. It is needless to say that the view of the joint obtained at operation is misleading, that frequently primary foci of disease are only recognized in post-mortem specimens by carefully sawing the bones to pieces. Most pathologists now believe that the disease begins in the bone and involves the joint later. Either the femur or tibia may be involved, generally the patella is inflamed secondarily; however, tuberculous ostitis of the patella alone has been reported four times by Gross; and 30 cases of primary tuberculosis of the patella have been gathered from literature.

The disease occurs at all ages. The age of incipiency for 100

cases at the Hospital for the Ruptured and Crippled, New York, is as follows:

One year or less, $2\frac{1}{2}$ percent; 2 years, $4\frac{1}{2}$ percent; 3 years, 9 percent; 4 years, 16 percent; 5 years, 8 percent; 6 years, 7 percent; 7 years, 7 percent; 8 years, 7 percent; 9 years, 6 percent; 10 years, 6 percent; 11 years, 4 percent; 12 years, 2 percent; 13 years, 2 percent; 14 years, 2 percent; 15 years, 2 percent; 15 to 20 years, 5 percent; 20 to 25 years, 5 percent; 25 to 30 years, 3 percent; over 30 years, $\frac{1}{2}$ percent.

FIG. 131.—Frontal section showing two tuberculous foci, one in each condyle. (*Children's Hospital.*)

Boys are slightly more affected than girls, and the left knee more than the right.

**Symptoms.**—The symptoms are pain, local heat, swelling, tenderness, stiffness, spasm, restricted movement, atrophy, and distortions. Seeing the child walk stripped attracts attention both to lameness and swelling of the knee. It is a valuable part of the physical examination. The enlargement at first may be slight, the surface about

the patella and the subcutaneous outline of the condyles and the head of the tibia are always obscured. The surface temperature of the skin is slightly raised, the joint, sensitive to deep pressure, may contain a slight effusion and resemble simple synovitis. In most cases, however, the usual test for floating patella shows thickening of the synovial membrane and capsule with but little fluid and the resistance under the finger is elastic, not liquid. The knee is a hinge-joint, the normal range of motion is from complete flexion, when the heel almost touches the buttock, to complete extension, 180° or a little beyond that point. Slight impairment of motion at both ends due to reflex muscular spasm is present at the onset.

FIG. 132.—Acute flexion and characteristic swelling and atrophy.

The disease begins insidiously. Slight lameness and slight restrictions of motion are the earliest signs and should always arouse suspicion of some sort of disease in the knee. As the swelling increases, palpation of the condyles and head of the tibia often shows a widening on the affected side which can be verified by measuring the distance between the condyles with calipers and comparing with a similar measurement of the sound knee. Complete extension of the knee becomes impossible because it brings more pressure on inflamed bone, and so we find little by little, flexion setting in with increasing stiffness and attacks of pain, the flexed knee becomes hot, tender, and sensitive to jar. As the bone inflammation in children begins in the epiphyses of the femur or tibia and near the joint surface of the patella, it has but a little way to travel to reach the joint, and it is, therefore, common for an invasion of the joint to come early.

After the joint cavity is involved it contains more fluid, the skin is hot, movements are much more restricted by spasm, the atrophy of the muscles of the thigh and calf is marked, and shortening may be present to a slight degree or it may not be noted till later, al-

though lengthening sometimes occurs from overgrowth of the epiphysis produced by inflammatory hyperemia in the neighborhood of the epiphyseal discs, and it may measure one-half inch longer than the other. Such overgrowth limited to one condyle adds knock-knee deformity. Knee flexion, however, makes it difficult to estimate this. Pain is not severe usually, exceptionally night-cries are a prominent symptom from the same cause as in hip disease. Malpositions of the limb result from the greater power of the hamstring muscles in the flexed position of the knee. This is not due so much to the size of the muscles as to the direct mechanical advantage of their line of pull. Flexion of the knee is a distressing symptom and one which is troublesome even late in the convalescent stage. The hamstring pull produces in time a backward displacement of the tibia, called subluxation of the knee joint, associated with external rotation of the tibia, or eversion, and usually with knock-knee which may be unrecognized until the limb is straightened.

FIG. 133. Extreme flexion deformity of left knee.

Abscesses are not uncommon. They may be cold abscesses, pure tuberculous ones, or they may start as cold abscesses and then become invaded by pyogenic organisms.

**Diagnosis.**—The diagnosis is easily made from the history of lameness, the peculiar enlargement, restriction of motion from muscular spasm, increased surface heat, and slight continual elevation of the body temperature. Owing to its superficial position, the knee is easy to examine. The radiograph is an aid to a precise knowledge of the lesion. By aseptic aspiration and inoculation in a guinea pig, the diagnosis of tuberculosis can be established.

**Prognosis.**—The outlook for a useful limb is excellent if protective treatment be early begun and faithfully persisted in. More or less stiffness of the knee is usual but a number of children have been known to recover with full normal motion and little shortening. Cases coming for treatment after long periods of neglect

can only expect to recover with deformity and disability. Some cases are very severe from the start; there is danger of permanent deformity in these.

## TREATMENT OF TUMOR ALBUS.

The treatment should include general treatment, conservative treatment, radical treatment, and symptomatic surgical treatment.

**General Treatment.**—Under general treatment the same attention should be given to increased feeding, abundance of fresh air for long periods, and general hygiene as described in chapters on hip disease and spinal disease.

**Conservative treatment** or local treatment is directed toward fixation and protection of the joint. Effective fixation may be obtained by a snug plaster bandage from toes to groin; short plasters from the middle third of the leg to the upper third of the thigh are manifestly inefficient. In some cases, however, the softness and fleshiness of the thigh renders a leg plaster inefficient; then a plaster spica extended to the toes fixes the knee. One must prevent the body-weight from resting on the affected limb. This can, of course, be done by recumbency or by means of a thick sole under the sound limb and crutches under the arms so that the limb swings clear of the ground, or a splint may be used as a perineal crutch. The ischiatic crutch of Judson, though designed principally for hip disease, is a good splint for this object. Better still, the Thomas knee splint. (Chapter XXI, page 373.) This splint can be used as a means of fixing the knee in a straight position by adding a leather knee-cap and straps combined with a broad leather band behind the knee to prevent forcing the joint into hyper-extended positions. The calf and thigh should be steadied by broad leathers laced. During the stage of convalescence, when spasm has disappeared but the limb still needs to be protected against sudden falls, the Thomas knee splint may be converted into a caliper splint by cutting off the foot piece and bending the ends to fit into a metal tube in the heel of the shoe. The splint should be too long for the heel to touch the ground. Blisters, and brushing with

the Paquelin cautery are useful as counter-irritants and to relieve pain temporarily.

Bier's treatment by passive hyperemia and dry heat is, according to that author's statement, of great benefit to some patients and of very doubtful utility to others.

**Resection of Knee-joint.**—We have already referred to the early location and removal of tuberculous foci in the hip. For the removal of these, resection of the knee-joint is not advised in young children because it produces excessive shortening from destruction of the epiphyseal cartilages; seven-eighths of the growth of the limb comes from the epiphyseal cartilages nearest the knee-joint. The knee-joint is, however, superficial, and the interior of the condyles of the femur and of the tibia are within easy reach of the surgeon's trephine or chisel. Starr, of Toronto, has reported excellent results from this method of treatment.

**Operations for Early Removal of Foci.**—Bernard Bartow, of Buffalo, recommends the following operation: An incision, about 2 inches long, is made through the skin, on the lateral aspect of the condyle, exposing the capsular ligament and periosteum freely enough to use the ordinary trephine—three-quarters of an inch; the periosteum and the margin of the capsular ligament are elevated together and reflected before trephining or removing a button with the gouge; the bone is then penetrated with a small sharp curette in search of a softened diseased area; when the curette enters it, the operator has a sensation of penetrating a cavity. The diseased tissue lies usually on the distal side of the epiphyseal disc and it may reach to the articular facet of the bone. It is surrounded with condensed bone on all sides. Bartow, after thorough curetting, swabs with a 25 percent solution of zinc chloride on a cotton pledget, after which the bone cavity is flushed with 1–2000 bichloride, and filled with 10 percent solution of tincture of iodine, or strong carbolic acid in glycerine, and part is allowed to remain. The periosteum and skin are sutured separately. The operation is not indicated if the joint is invaded.

Moorhof, of Vienna, has used his absorbable bone-filling in a similar operation with excellent results (see page 193). The perios-

teum is tightly sutured over the filling and the wound closed without drainage. Flexion is relieved by dividing the hamstring tendons unless their contraction disappears during etherization.

The end results, as regards motion in the knee, are excellent in Bartow's cases.

**Drainage of the Knee.**—Operative surgical interference is necessary in severe cases, either to evacuate pus or to correct deformity. General rules applicable to abscess about the hip are to be followed here also, and frequent examinations by radiographs should enable the surgeon to act more intelligently as the presence of a superficial abscess may be a sign of extensive destruction of the interior of the condyle of the femur or of the tibia.

**Arthrectomy.**—For the relief of persistent flexion and abscess which is rarely found except as the result of neglect, the joint has frequently been resected, and Ollier, of Lyons, devised the operation of arthrectomy or erasion of the joint. The destructiveness of these bone-abscesses about the knee is sometimes appalling; they are doubtless mixed infections. After breaking into the joint and from the joint into the surrounding tissues, the greater part of the thigh and leg may be invaded.

The operation of arthrectomy of the knee is performed by making an incision similar to that for resection of the knee-joint, extending from the external to the internal condyle, just below the patella, dividing the skin, the superficial and deep fasciæ, the capsule, the anterior portion of the lateral ligaments and ligamentum patellæ. By flexing the knee and dividing, if necessary, the crucial ligaments, the joint surfaces of the femur and tibia are freely exposed, and with a sharp Volkmann spoon the eroded articular surfaces may be opened into, and as much of the softened cancellous interior removed as possible. It is often feasible in this way to remove all the cancellous bone in the epiphysis of a child.

Tuberculous abscess walls may be freely curetted or treated with strong carbolic, and alcohol, with tincture of iodine, or with nitrate of silver solutions. The ramifications of the abscess in the thigh should be thoroughly explored and drained, after which the joint should be replaced in a straight position and the patellar ligament

securely sutured with kangaroo tendon, silver wire or silk worm gut. The joint should be sutured except at the sides where drains are placed; counter-openings into abscess ramifications should also be wicked.

While this operation in the hands of the writer has usually been attended by secondary septic infection beginning two weeks or

FIG. 134.

more afterward and while in some cases there has been shock, the results have been good. That is to say, the children got well with a stiff straight knee and with little shortening, after several months of suppuration, during which conservative treatment seemed far more dangerous to life than amputation.

## CORRECTION OF FLEXED KNEE.

Permanent flexion of the knee may be remedied mechanically or by operation. Traction may be used in bed by the apparatus shown in Figure 134. It may also be applied by means of the Thomas

knee splint (Chaper XXI, page 373). With the patient walking about, the splint may be bent at an angle less than the angle of his deformity. Traction is made upward above the knee by adhesive plasters attached to the thigh, and buckling on to the splint. Downward traction is made by plaster extensions below the knee attached to a ratchet and pinion traction bar at the bottom of the splint. Leather lacings for the thigh and calf fix the splint tightly to the limb. By means of the perineal ring the patient's weight is borne on the splint, and from time to time the gain may be compensated for by straightening the splint at the knee.

**Plaster Bandages to Correct Flexion.**—This method is applicable to flexion of short duration. During the acute stage or during exacerbations they should be applied to the knee without attempting to extend it, and changed once a week as it will often be possible to straighten a little at each successive application, the principle involved being complete rest with locomotion without weight-bearing. Forcible straightening may be done under ether, and if adhesions are absent, spasm overcome by anæsthesia permits immediate straightening unless subluxation is present. Adhesions may be broken up by manipulating the joint in various ways. The following method has been devised by Whitman, of New York, for resistant cases, especially if accompanied by a slight degree of luxation.

**Forcible Straighening under Anæsthesia.**—The patient, anæsthetized, is placed face downward on a table, with the feet projecting over its end. The body and hips are raised on a pillow until the thigh allows the shin to lie evenly on the table on a folded sheet. The operator with one hand holds the head of the tibia firmly against the table and with the other massages the contracted tendons of the popliteal space, exerting more and more downward pressure on the thigh but never allowing the shin to lift from the table. Little by little as the knee straightens the pillows are withdrawn. The deformity is often reduced in one sitting, but if very resistant incomplete correction is attained the first time, adhesive plaster straps for traction and a close fitting plaster bandage are applied, in order that the rest in bed with traction may be maintained. This method employs the body-weight of the

child's trunk to reduce the subluxation under ether. The correction under full anæsthesia of subluxated knees may also be accomplished by the genuclast of Bradford and Goldthwait. The apparatus resembles a great iron tuning fork with a screw pad four inches below the tips of the branches. The leg is put between the branches with the calf resting on the screw pad; and counter pressure is got from leather straps passing over the knee and leg protected by thick saddler's felt which allows great force ot be exerted by the screw without danger of pressure sores.

Adhesions may first be ruptured by forcible flexion. The apparatus is then put on the limb in a flexed position and the head of the tibia pushed forward as far as possible, and by lifting the end of the appliance which serves as a handle, the leg is then extended slowly. The forward pressure on the head of the tibia can be increased from time to time and the pressure on the knee altered if necessary by loosening the straps. Adhesions of the patella contra-indicate its use.

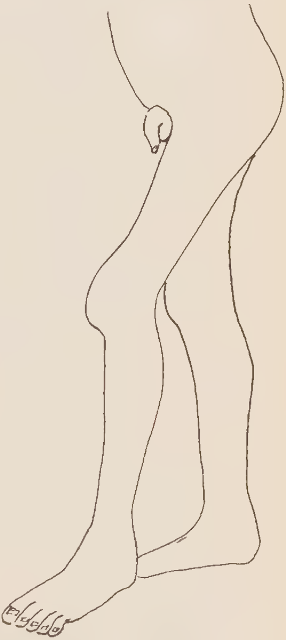

FIG. 135.—Subluxation of knee straightened without reducing deformity. A bad result.

**Operations to Correct Ankylosis with Flexion.**—When excision is done for angular ankylosis, the only modification which is necessary is the removal of a wedge-shaped bit of bone of proper size to allow the approximation of the sawed edges so that angularity is obliterated exactly.

Osteotomy of the femur just above the condyles has also been employed for the correction of flexion with ankylosis. By this means the straightened leg is healed with the lower end of the femur almost at a right angle to its shaft so that the lower extremity of that bone, when viewed laterally, looks like a golf club. The more nearly the

tibia lies in line with the femur the more security there will be in walking.

Ollier's operation of arthrectomy may be used instead of excision for the correction of angular ankylosis; it is only to be preferred to excision for children, because it is easier to avoid injury of the epiphyseal discs when removing small bits of bone with the chisel and curette, than it would be with a saw. The risk of operative tuberculous infection is, of course, less in correcting old ankylosed joints.

Amputation of the thigh is seldom necessary, and only as a life-saving measure.

Excision is a last resort preferable, perhaps, to amputation for cases in which conservative treatment has failed or where the disease is too extensive and the general health is failing. It is a far better operation for adults, where it is an excellent operation to correct flexion caused by bony ankylosis. The mortality between the ages of five and twenty is less than 10 percent. Ankylosis is the aim of the operation but it is not always attained and there is a tendency to flex in some even where ankylosis has apparently been secured. The technic of the operation is described in all the books on general surgery and is therefore omitted here.

## TUBERCULOUS DISEASE OF THE ANKLE-JOINT.

Tuberculous disease of the ankle-joint comes next in frequency to that of the knee. It is frequently associated with tuberculosis of the hip, knee or spine. It is common in little ones, and has been known under the names of strumous or scrofulous disease of the ankle, caries of the ankle, and chronic ankle-joint disease.

**The pathology** of the affection does not essentially differ from that of hip disease, but the small bones of the tarsus are in early childhood largely cartilaginous and their destruction may be rapid and complete. When this condition can be localized in a single tarsal bone by the radiograph, time may be saved by a complete extirpation of that bone.

**Abscess** is even more frequent here than in other forms of bone tuberculosis. Gibney found it in 83 percent of his cases, Prendlesburger in 87 percent. This is probably explained by the super-

ficial position of the bones of the tarsus, which makes a small abscess apparent, whereas in the knee and hip it may often be overlooked if small because it is deep-seated. Owing to this superficiality an abscess may break before the process of re-absorption really begins. The affection includes both disease of the small tarsal bones and disease of the lower part of the tibia and fibula.

**Symptoms.**—Lameness comes early and the limp is a marked one, one may be lame from pain or from stiffness. Swelling is soon noticed, a boggy infiltration over the affected bone or over the ankle-joint, which is early invaded by tuberculous granulations. This invasion of the ankle-joint produces a swelling restricted sharply by the anterior annular ligament and the lateral ligaments of the ankle, so that a bulging is seen in front of and behind the malleoli. Pain and tenderness on pressure or on joint motion may be present; swelling and heat are always present. Muscular spasm is also marked at the limits of motion, and joint motion is much limited. The swelling is more diffuse if an abscess be there for then the depressions from the ligaments disappear and the ankle and foot become uniformly swollen.

The usual malposition is an equino valgus from muscular spasm which relaxes under ether or when joint irritation is over. Atrophy of the thigh and calf accompanies it. The restriction of ankle motion is less, the farther away from the real ankle the disease is, e. g., if the os calcis is diseased the ankle-joint often escapes. A history of preceding trauma is not infrequent.

**Diagnosis.**—In childhood the affection is only liable to be confounded with sprains, and chronic sprains are ever suspicious in children. In fact in children any chronic painful disease, associated with a slight rise of temperature and confined to a single joint whose motion is limited by muscular spasm which is held in malposition, is tuberculous almost ninety-nine times out of a hundred.

In adults, infectious and rheumatoid arthritis, gouty arthritis, and cancer may be hard to differentiate. The X-ray is of great value and should be used both for diagnosis and to watch the progress of tuberculous invasion.

**Prognosis.**—Excepting in neglected cases or where the disease

has been attended with excessive and prolonged suppuration, the prognosis in children is very good under conservative treatment. A serviceable foot, even after extensive suppuration and destruction of bone, is most always the result. The prognosis is somewhat better when the astragalo-tibial joint is not invaded. Conservatism is less good for adults.

The writer has, however, recently had under observation a patient, 81 years of age, in whom this affection had lasted less than a year. Conservative treatment had been employed and apparently with benefit. Bone destruction was slight; two small abscesses had left sinuses and one of these had closed. The radiograph showed evidence of the commencement of the healing process. This illustrates the fact that conservatism may be useful in adults.

**General treatment** is as important as it ever is in tuberculosis. As a rule, however, the use of crutches and sticks, plaster bandages, or iron splints has allowed the child with ankle disease to retain almost the activity of a healthy child. Hygienic surroundings, abundance of fresh air, very generous and nutritious feeding, should be used to sustain the general health.

**Local treatment** involves fixation by plaster bandages and protection from weight-bearing. Fixation should be complete in the acute stages, but a little restricted motion of the foot may be allowed at other times. Protection from weight-bearing may be accomplished by a high sole and crutches but it is more efficacious to use the Thomas knee splint. (See Chapter XXI, page 373.)

*Abscesses* are more apt to break here and less apt to absorb; therefore, they fall more frequently under the surgeon's knife than do cold abscesses of the hip. There exists, however, the same danger of infection from the operation or subsequent dressings, either from tuberculous or necrotic matter left behind or from sepsis introduced from without. An X-ray should be taken before operating to detect the presence of necrotic bone. Where this is absent a small incision without further disturbance is best.

**Excision of a Tarsal Bone.**—Where a single tarsal bone is largely destroyed by disease, it should be removed entire. Otherwise, necrotic bone or softened bone should be removed with a sharp

Volkmann spoon, if in the os calcis; in other parts of the tarsus, this procedure is less satisfactory. Before removing diseased bone, the surgeon should consider whether the disease will be arrested by the procedure or even if it will be benefited. As a rule, partial operations, gouging and scraping, are far more harmful than the complete excision of the bone, which can often be removed leaving the periosteum. Sub-periosteal resection of the lower epiphysis of the tibia and astragalus has been successfully performed.

**Excision of the Ankle.**—The writer prefers the route of Kocher for excision of the ankle. The patient, anæsthetized, lies on the face with the outer side of the foot up, a curved incision is made along the outward border of the foot just below the external malleolus reaching from the extensor tendons to the tendo Achillis. The peroneal tendons are found in their groove and divided, after attaching two silk guides, between which they are cut. The external lateral ligament is divided and the joint opened freely by twisting the foot inward so that it is entirely dislocated and both joint surfaces can be inspected to any extent and offer a fair field for removing whatever is best. After accomplishing this the foot is reduced to its proper position, the lateral ligament sutured, the peroneal tendons united, and the wound closed with superficial sutures. A small sterilized dressing and plaster bandage is then applied with the foot in a correct position. Heavy dressings and prolonged immobilization in the same plaster are used for two months to insure complete repair of the ligaments and tendons. After excision, weight-bearing should be prevented for eight or nine months by the Thomas knee splint. Amputation is rarely if ever needed in children, and finds its chief utility in young adults who cannot afford to lose many months from their business.

Dactylitis in the foot, disease of the metatarsal bones and the phalanges, is considered in text-books on general surgery and will, therefore, be omitted. The protection from weight-bearing is essential.

## TUBERCULOUS DISEASE OF THE SHOULDER-JOINT.

Tuberculosis of the shoulder is an insidious chronic affection prone to suppuration and eventually resulting in a stiff joint. It is

fortunately not common. Young found tuberculosis of the shoulder in $\frac{3}{10}$ percent of orthopedic hospital cases. The disease is often associated with disease of other joints. It may begin at any age. The primary focus is in the head of the humerus usually, but the scapula may be diseased separately or in conjunction with it. A few cases were supposed to originate in the synovial membrane.

**Symptoms.**—The pain is distressing—a dull, aching pain, worse at night, referred to the shoulder or the middle of the humerus; there is tenderness in small areas anterior or posterior to the joint; the arm is instinctively kept quiet; passive motion evokes muscular spasm; the humerus and scapula move together; the joint contour is changed early from atrophy of the deltoid and enlargement of the head. Looked at from above the joint looks wider in an antero-posterior direction and flatter externally. Natural depressions are obliterated. Suppuration often leads to complete destruction of the head of the humerus with, in time, ankylosis and a weak and often much shortened arm.

**Treatment** demands the same general building up as in all forms of tuberculosis. Local treatment is very unsatisfactory.

The weight of the arm gives traction to the joint in the erect position. Abscess usually leads to prolonged suppurating sinuses.

*Excision of the joint* is often necessary both in adults and children. In adults it is the operation of choice as soon as the diagnosis is indisputably established. It may be excised through an anterior incision or a posterior one. The periosteum is divided with a bone knife along the inner border of the bicipital groove. The arm rotated outward and inward allows the ripping up of the periosteum and the muscular attachments as they appear. The Gigli saw is used to remove as much of the bone as is diseased, after the head of the bone has been thrown out of the wound. Fixation can be obtained by strapping the arm to the side with a thick pad between body and arm. A light plaster-of-Paris bandage including the arm and chest affords thorough fixation. Late excisions when the joint has been distended with pus, perforated, and many sinuses have developed, are practically impossible to free from tuberculous material

at the time of operation. The use of iodine, carbolic acid, or alcohol is here desirable and some drainage should be maintained.

Amputation is only a life-saving measure as the more conservative operation of excision accomplishes almost the same thing. The disease may last for years.

## TUBERCULOUS DISEASE OF THE ELBOW JOINT.

Tuberculous disease of the elbow-joint is almost as common in childhood as disease of the ankle. Girls are more frequently affected than boys; no one knows why.

Koenig gives the ages as follows:

Under 10 years, 25 percent; 10 to 20 years, 20 percent; 20 to 30 years, 12 percent; 30 to 40 years, 15 percent; 40 to 50 years, 8 percent; 50 to 60 years, 14 percent; 60 to 70 years, 6 percent.

**Symptoms.**—The primary focus is generally in one of the bones, the ulna originating almost one-half. Tuberculous ostitis here is usually in the olecranon or close to the epiphyseal line, that is to say, close to the articulation with the humerus, hence joint abscess or the invasion of the soft parts about the joint is frequent. The forearm cannot be extended, but flexion, pronation, and supination are free in the early stage, and the surface temperature is often increased. Swelling may begin at the side of the tendon of the triceps. Wasting of the arm and forearm shows early; stiffness progressively increases; movements are limited by muscular spasm; the joint is usually held at an obtuse angle; starting pains by day and night-cries may become the source of great discomfort; the swelling generally-fusiform may grow very large; areas of fluctuation appear; sinuses follow; the whole region about the elbow becomes pulpy in untreated cases or in those which relapse; limitation of rotation of the forearm arouses suspicion of tuberculosis in the head of the radius.

**Prognosis** is for eventual recovery with a stiff elbow unless conservative treatment be maintained from the start or a successful excision be done.

**General treatment** should be employed as for tuberculosis elsewhere.

**Local Treatment.**—Fixation is best furnished by plaster-of-Paris or molded leather, frequent removals and re-adjustments disturb and injures the joint. A sling to be worn properly should support the hand as well as the arm. The elbow should be flexed, if possible, to a right angle, to insure a useful position of the arm, should ankylosis occur. The rest afforded by successive plaster bandages, changed every two or three weeks, may be sufficient to secure the right-angled position, for rest will quiet muscle irritation and spasm.

*Excision of the Elbow.*—If the disease be progressive, excision or arthrectomy are to be preferred to conservative treatment, but in early childhood, cures with a better range of motion are obtained without operation. Excision is also indicated for ankylosis in malposition. Excision is done through a posterior incision about 5 inches long with the olecranon in the center,—a longitudinal incision which is carried down to the bone. Periosteum and soft parts are lifted from the humerus by a periosteal elevator; the bones are dislocated; the periosteum is removed from the humerus anteriorly and its articular end sawed off. The same is done to the proximal ends of the radius and ulna. In childhood, as little material should be removed as possible and yet leave no tuberculous bone. Iodine, carbolic acid, or alcohol may be used if the ramifications of the abscesses and sinuses cannot be easily excised. Thorough fixation which will allow change of dressings and the early abandonment of wicks may be secured by immobilization of the arm and hand and the application of a plaster bandage which is bivalved. If the muscles and ligaments are not badly damaged, passive motion may begin in three weeks, but the immobilization must be maintained for months with daily slight movements given and controlled by the patient. The fatality of the operation is very slight.

Kocher obtained cure in 96 percent of his cases, and two-thirds of his patients could use the arm for hard work. Koenig's results were less satisfactory, and those at the Children's Hospital, in Boston, also are less satisfactory.

Excision of the elbow is done to cure ankylosis in malposition. The after-treatment is the same. In many cases where it is shown by the radiograph that foci are small and isolated, partial resections

devised to suit the individual case are often of great benefit. Bradford says that passive motion is undesirable, as a rule, except in adults who have been operated upon for ankylosis or comminuted fracture and whose ligaments have been well preserved during operation. A movable elbow in childhood after resection is too apt to mean a weak flail joint.

### TUBERCULOUS DISEASE OF THE WRIST-JOINT.

Tuberculous disease of the wrist, metacarpus and phalanges is considered in text-books on general surgery, and does not differ materially from tuberculosis of other joints.

Wrist disease is attended by swelling, heat and stiffness. The hand is flexed and the joint is enlarged. In destructive disease the forearm and hand are swollen and suppuration occurs often, motion is limited by spasm, muscular atrophy is present, the skin over the wrist is usually hot.

Diagnosis is usually easy and the radiograph of great assistance. Fixation in splint or plaster and carrying the arm in a sling is recommended.

Excision of the joint is indicated for children who, under conservative treatment, get progressively worse, and in adults whenever the disease is destructive.

**Passive Hyperemia Treatment for Tuberculosis.**—In the knee, ankle, elbow, and wrist, the treatment of tuberculous disease by venous stasis or by enclosing the limb in a chamber from which the air is exhausted has been extensively tried by Bier and Klapp, in Bonn. The application of a rubber constricting bandage was first made; only lately has suction treatment come into vogue.

At first constriction by a turn of rubber bandage above the joint was used only for one or two hours a day or twice a day; if swelling took place, treatment was abandoned until it disappeared. Cold abscesses appeared, they grew rapidly; fistulæ sprouted large masses of granulations and some joints had acute exacerbations of pain and tenderness, and this treatment was not well thought of. However, good results were obtained in one tuberculous shoulder where the hyperemia had been maintained for daily periods of

twelve hours. It was then tried for long periods of time, producing rapidly an edema which became chronic and so excessive that the treatment had to be abandoned in a few days. Pauses were made between periods of treatment sufficient to allow this edema to subside and the following precautions are now taken by Bier.

Hyperemia should never be allowed to cause pain. If it does it is used wrongly. The bandage should be changed if it makes the limb cold, the skin should be as warm as that of the other limb. Hyperemia for seven to twelve hours a day certainly reduced the tenderness and pain in the joints. After this had been accomplished the period of hyperemia was gradually diminished until often several weeks or months had elapsed, when it was used for only one hour a day. Edema was found only in the first days of treatment. By elevating the limb between treatments it would disappear. Cold abscesses then appeared as infrequently as usual, they did not increase rapidly, and they were drained early; complicated dressings were avoided, and sinuses were never wicked. Under this treatment, the following good results were *reported by Bier:* 17 cases of wrist-joint disease, 4 of which presented fistulæ at the beginning of treatment, 5 others had abscesses opened during treatment, all had useful motion and 3 perfect motion at the conclusion of treatment. No deformity resulted although subluxation of the wrist and complete stiffness of fingers and hands had been present. Two had many abscesses. In wrist-joint disease, the duration of treatment by hyperemia was usually about twelve months.

**Elbow-joint Disease.**—Eleven cases treated; 5 of them with fistulæ at the beginning of treatment; 8 required incision for drainage of abscesses of whom 2 still have fistulæ. Normal motion was never secured but a useful amount of motion was present in all. The average period of treatment was nine months.

**Tuberculous Disease of the Foot.**—Thirteen cases were treated; 8 of them with fistulæ at the beginning; in 6 abscesses were drained; 8 cases were well, 3 improved, 1 not improved, and 1 was amputated outside of the clinic. The average period of hyperemia treatment was ten months. Full mobility of the ankle and foot was obtained in 3 cases, and a useful position for walking in all.

**Tuberculous Disease of the Knee-joint.**—Five cases were treated, 2 with abscesses, 1 with fistulæ; 3 cases were cured and 2 were improved; 2 had full motion of the knee, and 1 was stiff but in good position. The 2 improved cases had a stiff knee; 8 more cases after short periods of hyperemia treatment underwent resection.

**Tuberculous Disease of the Shoulder-joint.**—One case, which healed with normal mobility.

The worst results have been observed in the knee, where resection of the joint was necessary 8 times out of 13. There seems to be no regularity in the results. The best results are found in tuberculosis of the wrist and hand.

**Suction Apparatus.**—Klapp has recently, instead of using the constricting bandage, placed the limb or joint in a glass vessel from which the air was exhausted; by this means hyperemia is established. He confined himself to cases with abscesses or fistulæ. This hyperemia can be localized over the tuberculous areas if they are superficial, but not if they are deep and far distant, as is the case in caries of the spine. The most convenient appliance for a fistula is a cupping glass with a bulb to exhaust the air.

The form of cupping glass must be altered to suit the part of the body but a few different shapes are sufficient. The glass is rendered aseptic by soaking in a 1–1000 corrosive sublimate solution. The method of application is not different for bones, glands, or other forms of tuberculosis. At first, the cup should be applied for three-fourths of an hour every day; after it has been applied for five minutes, it should be taken off for three and reapplied, and it should not be used beyond a point when pale, flabby, tuberculous granulations change into red, tough ones. At that time the treatment should be changed from daily to once every three to eight days. The results in those with fistulæ and abscesses, Klapp thinks, are better than with passive hypernia from the bandage. In order to secure adaptation of the cupping glass it is necessary to cleanse the skin with benzine and apply lanoline or vaseline to the edges of the glass. This is removed from the skin with benzine as soon as the glass is taken off.

## CHAPTER XVII.

# DISEASES OF BONES AND JOINTS FROM DISORDERED NUTRITITION.

## SCURVY.

Scurvy, scorbutus, is a constitutional disease from malnutrition; its usual cause is deprivation of fresh food.

**The symptoms** are anemia, ecchymoses and subcutaneous hematomata from slight causes, bleeding under the mucous membrane of the mouth or from the gums. This bleeding from the gums comes from a stomatitis ulcerosa and occurs frequently when there are teeth; it is a necrobiosis in the mucous membrane and tissues of the gums at the borders of the teeth.

In infants scorbutus has followed the use of many of patented infant foods and has also occurred occasionally in those who were fed on sterilized milk.

In 379 cases of scurvy reported to the American Pediatric Society, swelling in or about the joints was observed in 45 percent; and rickets was present in 45 percent. No special microorgansim has been found to cause scorbutus.

**Pathological Anatomy.**—The pathological changes are hemorrhages under the skin, in among the muscles or tissues surrounding the joints, occasionally into the joints themselves, but the hemorrhage is oftener under the periosteum of the long bones. The long bones of the arm and leg are most frequently the seats of this subperiosteal hemorrhage. Interstitial hemorrhages in the lungs, spleen, kidneys, and intestinal glands, and hematuria have been observed. Separation of an epiphysis from the shaft may occur from this bleeding in infancy. The common age for scorbutus in childhood is from eight to fifteen months.

**Diagnosis.**—Clinically they have swellings of the leg and fore-

arm bones which are very tender to pressure but there is no increase of surface temperature, and ecchymoses appear in the skin and around the gums and lining of the cheek.

Rotch observes that the mucous membrane of the gums is affected only when teeth are present or a tooth is coming. The infant keeps the affected limb or limbs perfectly stiff to avoid painful movement, a condition called pseudo-paralysis, as his tenderness is then extreme. It is easily differentiated from rickets but the two conditions may occur together. Purpura lacks the subperiosteal hemorrhages. Pain is present only occasionally on the first day of an acute infantile paralysis and there are no large ecchymoses. Hemorrhage into into the joints and under the periosteum has led to an erroneous diagnosis of osteomyelitis or acute arthritis of infancy which it may resemble except for the absence of fever. Hence, free incision has been made through the periosteum, the blood was under such high tension that the whole shaft of bone immediately popped out. A new tibia grew later from the periosteum. In some cases a knee-joint may be full of blood, and much swollen. When subperiosteal hemorrhage alone is present, there is a swelling of the shaft just above the epiphysis.

Ridlon, and Taylor have described cases of scorbutic disease in the vertebræ. Acute pain in one case had been present for three weeks; passive movements of the legs caused crying; even rolling the child over in bed gave extreme suffering; the spine arched forward and was held rigid throughout its entire length. With appropriate diet the child was well in two weeks. No swellings were found in the thighs, legs or forearms, and no elevation of temperature. This condition is probably more common than is realized.

**Treatment** in these cases should be conservative and medical. Babies should be kept on a pillow, and painful movements avoided. The essential thing is to change the food to a diet of fresh milk and orange juice. Orange juice for the baby is what lime juice is for the sailor. Babies should be given the juice of one orange a day and if improvement does not rapidly take place, two oranges a day should be given.

## RHACHITIS, RICKETS.

Rhachitis or rickets is a disease of impaired general nutrition which is common among the children of strangers or those not yet acclimated. Acute rickets comes in the early years of life, the time of the most rapid growth of the skeleton. Improper feeding and unhygienic surroundings predispose to it, it may begin after protracted diarrhœa, vomiting, bronchitis, or broncho-pneumonia. Fetal rickets has been described but its existence is doubtful; late or adolescent rickets occurs but is uncommon. Rickets frequently attacks a whole family of brothers and sisters, but it is not known to be hereditary. The character of the disturbance of nutrition on which it depends is unknown. Boys and girls are equally affected.

The following table of ages has been compiled from various authors by Rotch:-

First year, $37\frac{8}{10}$ percent; second year, $44\frac{3}{10}$; third year, $12\frac{4}{10}$; fourth year, $2\frac{7}{10}$; fifth year, $1\frac{4}{10}$; over five years, $1\frac{4}{10}$ percent.

It is essentially a disease of the temperate zone; and flourishes best in cold, moist climates: it is unknown both in arctic and tropical and is rare in subtropical countries. It is also uncommon in high altitudes. It is exceedingly common in all classes of life, more so than was formerly supposed, especially in large seaboard cities. Morse found that 80 percent of the patients at the Infants' Hospital, in Boston, under two years of age, showed some of the bone changes characteristic of rickets. Softness and bending of the bones in rickets may be generally distributed or localized. It may come in breast-fed infants but as it is rare during the first six months, this may be accounted for by the deterioration in the quality of the milk after the first six months of lactation.

**Pathology.**—The principal lesions of rickets are those in the bones. The bones normally grow in length by the production of bone tissue between the epiphysis and shaft; in circumference, by a growth of bone from the inner or osteogenic layer of the periosteum; the endosteum also forms bone. Cancellous bone formation between the epiphysis and shaft is retarded and abnormal, in rickets.

An irregular overgrowth takes place there which causes an apprecia-

ble enlargement, but the tissue of this overgrowth is not bone but osteoid tissue, a soft yielding tissue consisting of a hyaline matrix and cartilage cells slightly altered but not transformed into bone cells, a tissue which never ossifies and grows most irregularly so that the line between the shaft and epiphysis is wavy and irregular and the juxta-epiphyseal region is much widened and thickened. The osteogenic layer of the periosteum is also much thickened, the cells are large, juicy, and irregularly arranged, and instead of depositing hard concentric layers of lime and new bone cells, there is formed partly osteoid tissue, partly cartilage, and partly true bone. The bone is weak because new bone ceases to form, it is also eaten away to a varying degree from within by the action of the giant cells (osteoclasts) which pass in along the Haversian canals and also attack the walls of the general marrow cavity. It is not surprising that such bones bend or break, or that the region where the epiphysis joins the shaft enlarges. Owing to bone absorption by the giant cells the medullary cavity enlarges, the cortical bone is thinned and weakened and partly replaced by soft osteoid tissue and so allows the bone to bend under the strain (pressure) from body-weight or muscle pull. Enlargement of the spleen and liver are usually noted. Spontaneous fractures have sometimes occurred and they are often not recognized except by the X-ray.

The deformities of rickets which the orthopedic surgeon sees are coxa vara, bow-legs, knock-knees, flat-foot, curvature of the spine, deformity of the chest, and a few deformities of the arms.

## COXA VARA.

Coxa vara is a frequent rhachitic deformity. Its treatment is the same as non-rhachitic coxa vara (see chapter X, page 145).

## BOW-LEGS.

Bow-legs, genu varum, genu extrorsum, out-knee, bandy legs, Säbelbein, Sichelbein, O-bein, genou en dehors. Bow-legs may represent an outward lateral or a forward bowing of the thigh, the leg, or both. A bowing curve of both thighs and legs produces the

outline of the letter O, hence the German name O-bein. It is the commonest of all rhachitic deformities. In Children's Hospital, in

FIG. 136.—Anterior bow-legs—in addition to curves it shows that the enlargement is in the shafts next to the epiphyses; not in the epiphyses. (*Children's Hospital, A. W. George, Radiographer.*)

Boston, bow-leg is present in about 13 percent of the orthopedic out-patients, and it is more often double than single.

**Bowing of the Femur.**—Bowing of the shaft of the femur usually has the convexity directed outward and forward. There is thickening of the bone where it bends on the concave side. In extreme cases the medullary cavity is narrowed or bridged over. Spontaneous straightening by growth has often been observed with restoration of proper relations at the knee. Usually the whole shaft bends evenly but many cases are seen where the lower end of the shaft is bent sharply with forward convexity. Femoral bowing may be produced by ankylosis of the knee in a bent position, and these low-seated bends are sometimes neutralized by a sharp bend of the tibia just below the head.

Bad deformity of the thigh may demand osteoclasis or osteotomy,

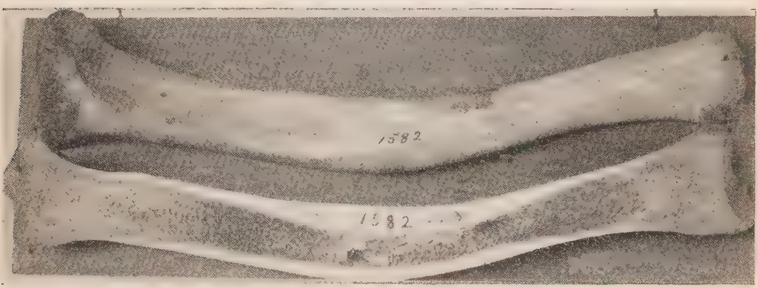


FIG. 137.—Adult bow-leg. Tibia showing adaptive thickening of cortex. (*Warren Museum.*)

followed by overcorrection in a plaster spica for three months; during the last month, however, the patient is allowed to walk in his plaster bandage. As the curvatures of the thigh are apt to recover if left to themselves, this operation is seldom performed on children under seven or eight years old.

**Bowing of the Tibia and Fibula.**—The bow-leg deformity usually has its seat in both tibia and fibula, and the curve may be lateral or antero-posterior. The most frequent point of curvature is at the junction of the middle and lower third of these bones. A child with lateral bowing stands with the legs apart and the deformity is plainly seen as he walks in the street; his gait is a waddle, the body leans at each step and the child usually toes in. If coxa vara

co-exists abduction is restricted and the equilibrium is adjusted by keeping the knees partly flexed. It is very unusual to have any pain.

**Diagnosis.**—The diagnosis is evident on inspection. In little babies the tibia may seem slightly curved when it really is not, or they may be bowed without rickets. These usually get well unaided in a few months. To estimate the amount of bowing in the femora the legs should be crossed until the inner condyles are in contact, when the deformity of the thighs becomes evident Although it is well known that bow-legs are frequently outgrown, there are no data on which to form an opinion as to the chance of outgrowing the deformity in a given case.

FIG. 138.—Tracing of bow-legs.

**Treatment.**—With suitable treatment, mechanical or operative, any child can be permanently cured, and in adults the bow-legs may always be improved by operation. Anterior bow-leg is not amenable to mechanical treatment but is readily cured by operation. Some think that operative treatment in small children should be postponed because of their liability to relapse, owing to their soft, yielding bones; sufficient hardness may be expected when the tibia has grown to a length of seven inches. During the period of expectant treatment a tracing of the outline of the leg should be taken once a month and compared with the previous one to watch for increase or decrease of the deformity. Walking should be discouraged. Thrice a day the mother should grasp the ankle in one hand and press upon the point of greatest deformity with the other endeavoring to straighten the leg; or the child should sit with the ankles touching and the legs be pressed together by the flat of the mother's hand. Tracings are made (Fig. 138) by seating the child with legs and

hips bare on a piece of paper sufficiently large, placing the ankles and great toes in contact, while the surgeon with a pencil, always kept vertical, marks the outline. Up to four years of age, braces may benefit bow-legs. See Chapter XXI for braces.

They should be worn day and night or a special night brace may be used in bed. When sufficient improvement has been secured, they may be discontinued by degrees.

*Operation* is indicated in children who are old enough, and even for slight deformity in anterior bow legs.

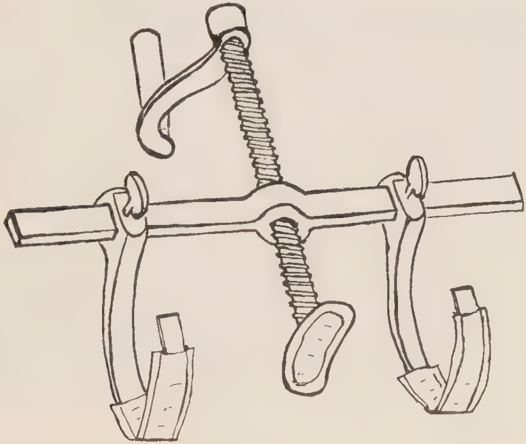

FIG. 139.—Bradford's modification of the Rizzoli osteoclast.

**Osteoclasis** consists in breaking, setting and holding a leg as for a simple fracture. The break should be made at the point of greatest curvature. The operation may be performed by the hands of the surgeon, bending the leg over a folded sheet on the edge of the table. But this requires unusual manual strength and an osteoclast is usually employed. Osteoclasts of various kinds have been devised. That of Rizzoli is, perhaps, most commonly found in hospitals. A. Meyers, Heusner, Grattan, R. T. Taylor, Keen, and Bradford, have recently devised excellent osteoclasts. Speed in the use of the osteoclast prevents pressure sores and its exact control in the hands

of the operator is the safeguard against compound fracture. All osteoclasts break efficiently near the middle of a bone. The points of counter-pressure should be over the end of the shaft, as it is otherwise possible to separate an epiphysis. After osteoclasis the leg is put in plaster, straight or slightly overcorrected. Rotation of the foot is also corrected and a properly padded plaster-of-Paris bandage is applied from the toes to the groin to be worn from eight to twelve weeks.

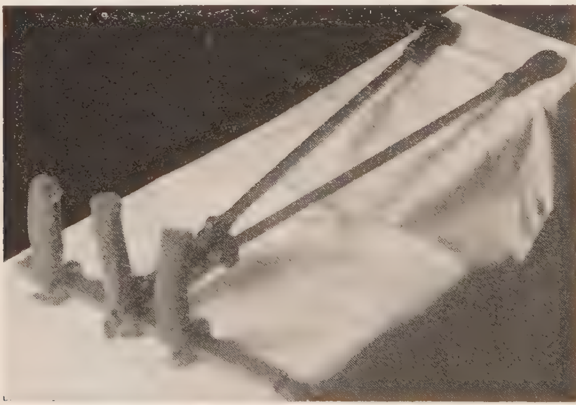

FIG. 140.—Keen's osteolast. (*Children's Hospital.*)

**Osteotomy** is to be preferred whenever the point of greatest curvature is near the end of the diaphysis or when a marked anterior or antero-lateral bowing presents any peculiar features which might make osteoclasis difficult. Cuneiform osteotomy is unnecessary and produces shortening. In severe, sharply localized curves the removal of a wedge may be avoided by driving the chisel into the concave side of the bone, incompletely dividing it and opening up the bone carefully in straightening with the hands, so as to leave an unbroken attachment. No incision is necessary for linear osteotomy. The chisel or osteotome (a chisel sharpened like a simple wedge less than one-half inch wide) is driven through the skin parallel to the axis of the bone until the edge engages; then it is turned at right

angles to the shaft and with light blows driven into the bone, dividing first the upper, then the lower edges of cortical bone and partially dividing the side of the bone away from the operator; the fracture is completed by the surgeon's hands. Both the fibula and tibia should be partially divided before attempting fracture. The small incision made by the osteotome bleeds very little. It is dressed with sterilized cotton, the limb enveloped in cotton wadding and a plaster bandage applied as after an osteoclasis.

FIG. 141.—Anterior bow legs.

**Anterior bow-legs** may be corrected either by osteoclasis or osteotomy. The osteoclast is applied to the *side of the leg* so as to locate the break at the point of greatest curve, otherwise the sharp anterior ridge of the tibia may perforate the skin under the pressure of the osteoclast. It is desirable to perform subcutaneous tenotomy of the tendo of Achillis so as to prevent recurrence of the deformity, because the soleus and gastrocnemius act strongly like the string of a bow. In anterior bow-legs *osteotomy* should aim to divide the posterior, inner and outer surfaces of the shaft with the osteotome, leaving the ridge of the shin to be broken or bent by the hand. This prevents any displacement of fragments and shortening, but demands some skill in the use of the osteotome.

## KNOCK-KNEE.

Knock-knee; in-knee; genu valgum; genu intorsum; X-Bein; Bächerbein; genou en dehors; genou cagneux; ginnocchio valgo. Knock-knee means inward prominence of the knee, the femur and leg bones, forming an angle with each other, opening outward. It is about one-half as frequent as bow-legs at the Children's Hospital, in Boston. It is rarely congenital, but sometimes arises from fracture or separation of the epiphysis, from infantile paralysis, or follows bone disease, tuberculous osteitis or osteomyelitis; nevertheless most cases are from rickets. They may be one-sided or double or

we may have a knock-knee with a bow-leg on the opposite side. Unilateral cases may show shortening of the limb from distortion, a one-sided lowering or obliquity of the pelvis and lateral curvature of the spine from limping. Knock-knees are easily sprained; they have pain and are much impeded in their gait. By abducting and rotating the hip outward, they swing the knees around each other in walking, in a clumsy fashion, to prevent knocking. Both thigh and leg bones may be bent. Flat-foot and pigeon-toe frequently accompany it and the median side of the boot heel is always more worn than the outer. The bending of the femoral shaft is in the frontal plane and twist of the shaft of the tibia is often associated. This twist is in the direction of the outward rotation of the foot. The patella in severe cases lies over the external condyle. Boys are more frequently affected than girls; and it comes on sometimes during adolescence and is due to adolescent rickets. Coxa vara frequently coexists with knock-knee. Slight degrees of knock-knee are normal in women and in a few men. If a child cannot stand with his knees touching, his ankles together and his toes pointing forward, he has knock-knee.

FIG. 142.—Knock-knees. (*Children's Hospital.*)

There exists in knock-knee as in bow-legs a tendency to spontaneously outgrow the deformity, although no definite data have been accumulated to prove this statement. Severe ones cannot correct themselves. Moderate cases in young children are amenable to mechanical treatment, and slight cases in little, rapidly growing children may be cured by manipulation and general treatment. Even the severest cases are corrected by operation.

## TREATMENT.

**Treatment.**—In babies and little children, tracings may be taken and compared once a month, while daily manipulations of the extended knee are tried and may straighten. Infants learning to walk may need a support for the arch of the foot, and if so the inner border of the sole of the boot may be raised one-quarter of an inch. If they do not improve, treatment by mechanical appliances becomes imperative. The knock-knee splint (see Chapter XXI) pulls the knee outward to an upright on the outer side of the leg and also keeps it extended, for the deformity is greatest in the extended position. A night apparatus should also be used. Mechanical treatment is seldom successful after four or five years of age.

FIG. 143.—Manipulation to straighten knock-knee.

**Osteotomy** is the operation of choice in this country, although in Vienna and in Italy artificial separation of the epiphysis, epiphyseolysis, is much used. Macewen's osteotomy is a linear division across the lower extremity of the diaphysis of the femur, it is used even when the X-ray shows the seat of the deformity in the tibia. Schede, and Blanchard, of Chicago, however, have used linear osteotomy of the tibia and fibula in such cases. Macewen's osteotomy has been singularly free from fatalities. It is performed by driving an oseotome into the femur on the inner side of the thigh at a point just above the tubercle for the adductor magnus tendon. Incision is unnecessary, for the osteotome is driven in at right angles to the shaft and the femur is divided in the same manner as the tibia for bow-legs; the fracture is completed by the hands and the subsequent treatment is similar to that following osteotomy for bow-legs. The plaster bandage extends from the waist to the toes.

**Epiphyseolysis.**—This operation is a straightening by partly

separating lower epiphysis of the femur and must be limited to those who have not yet united the epiphysis to the shaft. It has been used extensively in Austria and Italy; Reiner has his patient lie on the side with the leg to be operated on uppermost, he puts the inner condyle on a block of wood firmly clamped to the edge of the table about five inches high and a little lower at the edge of the table; he uses this block as a fulcum, bringing the leg down so that the support stops three-quarters of an inch above the widest point on the condyles, he completely extends the knee, grasps it with the palm over the patella and with the forearm over the fibula presses downward upon it with slowly increasing force till the deformity is straightened. The edge of the fulcrum should be opposite the epiphyseal disc. A plaster spica bandage is applied and the after-treatment is like that for correction by osteotomy. Codivilla bends it over the edge of the table, Lorenz bends it in his osteoclast. In children who are still undergoing the softening of rickets an infraction occurs, not a separation of the epiphysis, and therefore this procedure should be limited to the years between eight and eighteen. The presence of a disc of cartilage is essential, so adolescents should be X-rayed to make sure of its presence.

FIG. 144.—Bow-leg and knock-knee.

FIG. 145.—Diagram of Macewen's osteotomy.

**Splint Treatment.**—The gradual correction of knock-knee by apparatus is restricted in this country to children less than four years old. In Germany, Julius Wolff, of Berlin, uses for older children the corrective plaster bandage. Wolff first applies a plaster bandage from the toes to the groin holding the knee as straight as he can while it sets. After

three days the bandage is divided by a circular cut around the knee, he removes a wedge-shaped piece from the inner side so as to allow further straightening of the deformity and approximation of the edges of the cut. While the leg is held in this position, more plaster bandage is applied around the knee and allowed to harden so as to maintain the gain. This process is repeated every three days until a slightly over corrected position is reached. The same bandages are worn for three or four months. It is necessary that the bandage be applied fairly tight especially at the top and bottom. After complete correction has been obtained broad hinge joints can be incoporated in the plaster so that the knee may flex without a return of the knock-knee deformity. A portion of the foot should be in the bandage. Wallace Blanchard, of Chicago, prefers osteoclasis to epiphyseolysis for the rapid correction of knock-knees, he uses the Grattan osteoclast and brings the point of fracture not far from the place selected by Macewen for osteotomy. Incomplete fracture or osteokampsis (green-stick fracture) may sometimes be accomplished by this means.

FIG. 146.—Lateral curvature from knock-knee of rickets.

## FLAT-FOOT.

Rhachitic flat-foot requires no different treatment from that of static flat-foot. See Chapter X.

## RHACHITIC SCOLIOSIS.

The rounded kyphos of acute rickets may demand recumbency for a few months.

Rhachitic scoliosis has been considered in chapter VII, page 105.

### RHACHITIC DEFORMITIES OF THE ARM.

The principal deformities of the arm consist in conditions of the elbow similar to knock-knee and bow-legs, in-elbow and out-elbow. Unilateral deformities of this sort may in rare instances give rise to scoliosis. This danger is an added argument in favor of correcting this deformity. In-elbow means that the hand and arm hangs by the side while the elbow is separated from it and objects cannot be carried at full arm's length without striking the leg. Attempts to obviate this produces a leaning to the side and eventually scoliosis.

Osteotomy has frequently proved of great benefit by correcting the deformity and straightening the arm. Peckham, of Providence, reports that a cure of scoliosis resulted. In little children the deformity may be watched by tracings as is done for bow-legs and knock-knees. Manipulations should first be employed. It is well not to operate too young as the deformity is sometimes outgrown like bow-legs.

### RHACHITIC FRACTURE.

Patients are occasionally seen whose rickets during the acute stage differs from those cases usually described in our text-books. The bones are, in the early years of life, unusually pliable, and children have been characterized by their crossness, and ill temper. If these cases be studied with the X-ray, the bones are found to be deficient in lime salts, very transparent, and frequently unsuspected fractures and partial fractures are detected. A case of this sort was described by Feiss and a recently taken X-ray negative showed the same condition in a child three and one-half years old, at the Children's Hospital. This condition borders upon osteogenesis imperfecta, osteomalacia, and rickets.

## OSTEOMALACIA.

Osteomalacia is uncommon in America. Its occurrence in childhood is comparatively rare even in places where it abounds. In adults it follows pregnancy. Osteomalacia is a nutritional disorder of bone characterized by a great decrease in the lime.

**Pathology.**—The pathology is still in dispute. Virchow believes that a solution of the lime salts of bone occurs, like the chemical process by which bone is decalcified in acid. Cohnheim, that the organic and inorganic constituents are destroyed by giant cells called osteoclasts and are replaced by new osteoid tissue free or comparatively free from lime. Von Recklinghausen found osteoblasts and islands of true bone

FIG. 147.—Osteomalacia girl of fifteen: Dr. Painter's patient. (*House of Good Samaritan.*)

in the osteoid tissue described by Cohnheim. The affection weakens both the compact bone of the shaft and the spongy bone of the ends of long bones. It is a general process throughout the skeleton. Goldthwait, Painter, Osgood and McCrudden found that bone of osteomalacia differs from normal bone in its chemical composition, being poor in lime and rich in magnesium, and in its relative propor-

tion of organic substances; it contains much sulphur and but little phosphorus. (It is somewhat similar in chemical composition to the normal organic matrix of bone.) McCrudden analyzed two ribs of a horse affected by osteomalacia and compared their analysis with that of two normal horse ribs. He showed a decrease in the calcium, an increase in the magnesium, an increase in the sulphur and a decrease in the phosphorus present, and the inorganic material of bone as a whole is greatly decreased. These softened, thinned bones bend and break easily, producing great deformity. After breaking a callus forms which may or may not solidify. The distortions are most irregular. The back is bowed, the chest flattened and the arms and legs are much twisted.

**The treatment** has been so far unsatisfactory. Fehling, in Germany, has cured many adults by ovariotomy, as he considers the affection a tropho-neurosis of bone, due primarily to diseased ovaries. Other surgeons, however, like Neumann, assert that ovariotomy does not materially affect the process; that the ovary is not always diseased, for the condition occurs in children before functional activity of the ovary begins, also in boys and men. That this treatment may mask for a time loss of calcium is probably all that can be claimed for juvenile cases. In *puerperal osteomalacia*, however, Fehling certainly had excellent results. Medication has offered no encouragement. Careful estimations of the ingesta and excreta have been made by McCrudden, showing an excess of calcium oxide in the excreta over that ingested. Possibly some dietary treatment may be evolved.

**The Spine.**—The pathological anatomy of the spine in osteomalacia has been described by Schulthess in Joachimsthal's Handbook of Orthopedic Surgery. There is marked increase in dorsal kyphosis, a slight increase in the lumbar lordosis, and frequently lateral curvatures. These changes are accompanied by marked lateral compression and increased downward obliquity of the ribs, with a flaring lower border of the thorax resembling Hutchinson's furrow of rickets and a flaring outward of the wings of the ilium and distortion of the pubic rami. The intervertebral discs are large in the center and the individual vertebræ markedly hollowed

to accommodate them. Schulthess found much less deformity than usual in the skeleton of a patient who was early bed-ridden as if weight-bearing were the essential factor in deforming the spine.

## OSTITIS DEFORMANS.

Ostitis deformans, described by Paget, in 1877, is also known as Paget's disease. It is essentially an affection of later adult life in which the bones enlarge, soften, and become unnaturally curved and misshapen. It is a combination of a rarefying and a formative growth of bone and it attacks the shafts of the long bones, the spine and the skull. Arteriosclerosis is so often associated with it that it has been deemed its cause and arthritis deformans may accompany it. The skull may be greatly enlarged and thickened. Rheumatic pains and headaches occur early in the disease but some never have pain, the general health is not affected. The attitude is characteristic; the bowed legs, well apart, support a rounded back and an enlarged head. The gait is clumsy and stiff, and the head droops forward toward the chest. The joints are not affected. Fractures are uncommon, and when they occur they unite readily.

In a series of twenty-five cases reported by R. B. Osgood and E. A. Locke, it was found that the average period of onset was between 43 and 44 years. Radiographs show both abnormal density and an increased thickness in the shafts of the long bones and in some places one finds obliteration of the medullary canal. In the leg, the long bones are bowed; in the arms they are not. The spine is usually bowed, more or less rigid and lateral curvature of moderate degree may develop. No satisfactory treatment has been formulated.

**Treatment.**—For the relief of quasi-rheumatic pain, which is probably due to a combination of arthritis deformans and ostitis deformans, Peckham recommends superficial cauterization once a month, and half-way between times the application of a blister on the side of the spine over the painful area.

Goldthwait thinks anything which increases the circulation diminishes pain; hot water, hot air, simply wrapping the parts in flannel or cotton, or gutta percha tissue may relieve pain.

Peckham believes that in some cases its progress has been arrested by counter-irritation.

## SECONDARY HYPERTROPHIC OSTEO-ARTHROPATHY.

This disease was first described by Marie, in 1890, since which time many cases have been reported. It comes as a complication of pre-existing chronic disease of the lungs, often developing in the train of pneumonia with delayed resolution. The deformity is a hypertrophy and an exaggerated clubbing of the fingers and nails and effusion into some of the joints. The hypertrophy seems to be caused by a deposit of layers of bone under the periosteum of the metatarsals, metacarpals, and phalanges, and in the distal ends of the bones of the forearms and legs. In a few cases, the femora humeri, and spine, as well, have been enlarged. It begins painlessly, with clubbing of the terminal phalanges and hypertrophy of the finger-nails. When the wrists and ankles become large pain and tenderness to pressure develop and it has been mistaken for a mild attack of rheumatism. But little is known of the nature of the disease, although the cause may be the absorption of toxins, from the primary disease, and that the hypertrophy may be analogous to amyloid enlargement of the internal organs in long-standing suppurative disease of the bones. The condition may become less marked, or, according to Whitman, may disappear if the patient recovers from the original disease of the lungs. It is very uncommon in childhood. Whitman records a case of complete recovery following the cure of Pott's disease and chronic bronchitis—the hypertrophied phalanges alone remaining. Although secondary hypertrophic osteoarthropathy may be due to the irritating presence of toxins, it may also be due to some disorder of nutrition.

## ACROMEGALY.

Acromegaly a condition of hypertrophy or unnatural enlargement of the hands, feet, fingers, toes, lower jaw, lips, etc., may resemble osteoarthropathy but the involvement of the face and head should

discriminate between them. The patients are often giants, with enormous hands and feet, and large, dull faces.

Sternberg divides the disease into three forms: First, the slight form where the changes are slight and the duration of the disease may be 50 years; second, the chronic form has marked growth of head, hands and feet and a duration of from 8 to 30 years; third, the acute or malignant form, has a duration of 3 or 4 years only.

After a period of growth a cachexia and muscular atrophy come on, cardiac dilatation and weakness render the patient very helpless, there are frequent nose-bleeds, and death usually is by syncope. Arthritis deformans has been observed in the early stage of acromegaly. The giants are not infrequently round shouldered and scoliotic. This condition is supposed to be due to disease of the pituitary body and is analogous to myxoedema from the thyroid gland. The pituitary is often sarcomatous.

## CHARCOT'S DISEASE OF THE JOINTS.

Charcot's joint disease is a destructive form of arthritis secondary to locomotor ataxia, but it may also be found with syringomyelia.

The articular cartilage becomes eroded, degenerates and wears away by the movements of the limb. The underlying bone is exposed and wears away, and meanwhile an exaggerated, irregular formation of cartilage and bone takes place about the periphery of the joint which is rarely distended with fluid. The capsule and synovial membrane are hypertrophied and may contain calcareous plates.

The knee is the joint most frequently involved. The hip, foot, and shoulder come next. Only 15 cases of tabetic spines have been reported. About one-quarter of the patients whose large joints are affected have joint disease of both knees, both hips, etc.

Pain is usually insignificant. The chief complaint is of weakness and insecurity; the progress of the disease is often rapid.

The diagnosis may be difficult when it is an early symptom of locomotor ataxia, as it may arise before the existence of tabes is suspected.

Arthropathy of the vertebræ has been studied by Spiller, of Phila-

delphia. It is characterized by a deformed position of the spinal column, lateral curvature and backward bowing. Some relief of pain may be expected from fixation in a plaster-of-Paris jacket.

The process in the hip is characterized by the acute onset of extensive joint changes; the synovial effusion is at times very great, a large fluctuating tumor presenting both at the front and the back of the joint, with crepitus from wearing away of the articular cartilage of the head of the bone; either spontaneous dislocation occurs or a migration upward such as is found in late hip disease.

Treatment consists in efficient support to prevent progressive distortion, while the underlying nervous affection must receive attention. Powerful galvanic currents have been recommended by Weir Mitchell to stimulate re-absorption of the effusion. Repeated aspiration of the joint sac accompanied by rest to the joint has been advised. Traction in bed may give relief from pain.

## ARTHRITIS DEFORMANS.

Arthritis deformans, rheumatic gout, rheumatoid arthritis, dry arthritis, osteo-arthritis, chronic rheumatism, malum senile, etc.

These terms have been used to describe chronic joint processes of unknown etiology which had this in common, that they were not tuberculous. Little is known of their etiology except that Schueller isolated a bacterium from the fringes of some cases and afterward claims that it is only causative of part of the cases of arthritis deformans. Goldthwait divided rheumatoid diseases into five groups or diseases, chronic villous arthritis, hypertrophic arthritis, atrophic arthritis, infectious arthritis, and chronic gout. For the sake of simplicity let us assume that the term infectious arthritis must include not only the majority of what is called arthritis deformans but also many other joint inflammations; it should not only be classed by itself but it should include all the different joint diseases produced by a specific infection with different microorganisms. Chronic gout also belongs in gout rather than here; and villous arthritis can be neither a disease nor a variety of a disease, for it only refers to joints which have undergone a peculiar proliferation of the

synovial membrane, a proliferation which occurs as the result of trauma, of many well-known diseases of the joints both nutritional and neuropathic like tabes, and inflammatory like tuberculosis and gonorrhœa.

If now one excludes from the list of Goldthwait infectious arthritis, villous arthritis, and chronic gout, there remain the hypertrophic and the atrophic arthritis which are here called two types of the old arthritis deformans, because although clinically they may be distinguished, they are usually at post-mortems associated in the same individual, when they may either represent an association of two different diseases or different stages of one and the same disease.

### THE ATROPHIC TYPE.

In the atrophic type one has to do with a progressive, painful joint affection attacking first the knuckles which are distended with a moderate effusion, the capsule thickened, and the articular cartilages thinned; slowly the cartilage disappears, the bone atrophies to a thin shell, the peri-articular tissues even the skin, wastes; owing to loss of cartilage the joint grates if moved: in time the bone becomes so thin that one side of the joint telescopes to some extent into the other producing deformities and partial dislocations; the final result is a small atrophied joint; but the disease is progressive and chronic and though it may stay in a single joint several months, it always extends to many joints before it stops spreading which it does not do for many years. The cause is unknown. Either a large joint or the knuckles begin the trouble and fingers are always affected very early. It is recognized most readily by the small crepitating joints. Goldthwait considers the prognosis good under efficient treatment. Others say that the disease progresses uniformly and slowly from bad to worse. In some it comes to a standstill and after awhile they become much better.

**Treatment.**—Locke and Osgood consider the open-air treatment indicated which one gives a tuberculous patient, preferably in a sunny, mild climate, living and sleeping out of doors. Anemia, malnutrition, nervous debility, obesity or emaciation should be corrected,

a search be made to discover any suppurative process and cure it anywhere in the body; cardiac and renal trouble must receive appropriate treatment. Locally, massage and joint movements, active and passive, to prevent fibrous ankylosis, and rest during painful attacks. Corrective operations may be needed to restore locomotion lost through contractions of knee or ankle, manipulations under ether or tenotomy, three weeks in plaster for the ankle, six for the knee. A flat-foot plate is often needed after manipulating the ankle and caliper splints to walk in after the plasters on the knee. In reducing knee-flexion the greatest gentleness is desirable lest the joint be irritated and made painful.

FIG. 148.—Spondyliti's deformans of Lovett.

### THE HYPERTROPHIC TYPE.

The hypertrophic form is described as "either a local or a general process characterized by thickening at the edges of the articular cartilages or at the attachments of the ligaments, forming ridges or nodes which become ossified and interfere in varying degrees with joint motion." It is a chronic inflammation of unknown cause characterized by a growth of osteophytes on the borders of the joints. The bone becomes very dense at the end, the articular cartilages may be absorbed or thinned where the joint surfaces press upon each other, but unlike the atrophic form the articular cartilage is thickened at the periphery. The osteophytes which appear about the dorsal and lateral aspects of the knuckles are known as Heberden's nodes. Osteophytes around a joint may limit its motion considerably; but there is little pain unless pressure be made on a new forming osteophyte. When the osteophytic enlargement presses on a nerve passing over it there is very severe pain.

In the spine, osteophytes grow from the antero-lateral attachments of intervertebral discs chiefly, and often seem to ossify the anterior common ligament on one or both sides; a beginning process produces a lipping of the vertebræ. The costo-vertebral articulations are sometimes involved. In the knee, shoulder, etc., the capsule and synovial membrane undergo chronic thickening and villi are present and a membrane of organized fibrin extends over the cartilage, forming a pannus and the cartilage beneath it disappears while in the periphery the cartilage is thick and osteophytes grow.

The treatment consists in preventing joint irritation during the period of active growth of osteophytes. This is accomplished by giving rest to the joint. Braces, splints, or plaster-of-Paris, may be used for this purpose.

Where less complete fixation suffices, strapping or a flannel bandage gives relief. Prolonged rest seems to round off the sharp exostoses, to reduce the hypertrophy of the cartilage, and produces in some a return of painless joint motion. Osteophytes are occasionally removed to relieve pain or to increase the range of joint motion, but pain is apt to recur. When acute attacks of pain are not relieved by rest, venous stasis, or sweating with rubber tissue, or the hot air baking may do good. Peckham, of Providence, recently reported that the electric light bath was efficacious to relieve pain.

The general health is little affected. Therefore, internal treatment is unnecessary.

## ARTHRITIS DEFORMANS IN CHILDHOOD.

Still's disease but lately was considered a tuberculous affection. The process starts at or before the period of second dentition; it is polyarticular, usually fever free, at times associated with enlargements of the lymphatic glands and spleen, it is characterized by the gradual onset of joint stiffness and swelling, but it may, however, come on acutely with fever, and chills. Girls are affected more frequently than boys. It is an uncommon disease. Several joints become stiffened and enlarged from a thickening of the capsule and swelling of the soft tissues outside

of the joint; muscular atrophy is pronounced; there may be profuse sweating; the skin may be shiny and easily acquires pressure sores; secondary anemia may be present.

The disease is incurable but at times an arrest occurs. Children with long-standing Still's disease are apathetic, listless, and emaciated; the skin sometimes has a brown color, suggestive of profound toxemia. After periods of joint enlargement lasting a year or more, a gradual subsidence takes place and the joint function usually is entirely restored; but, meanwhile, other joints have been affected.

In the patient from whom the illustration was made, the disease had been present for two years. The following joints were affected: 1 toe; 2 ankles; 2 knees; 1 hip; 1 shoulder; 1 elbow; 2 wrists; 3 fingers; other fingers had been and the swellings had entirely disappeared. Aspiration of a joint resulted in the withdrawal of only a few drops of clear fluid; no bacteria were found in it; later on, the swellings over the ankles were incised and small portions of the peri-articular tissues were removed and examined but no bacteria were found; the tissues were edematous and resembled a myxomatous tissue.

Cases seen early are often benefited by massage and baking. Passive motions during the massage are better than too much exercise.

## GOUT.

The joints of gout are probably irritated by the presence of poisonous substances generated through imperfect tissue metabolism, not by bacteria or their toxins, but it must still be regarded as a disease of unknown etiology.

Gout is a constitutional affection, characterized by acute inflammatory processes in the joints, which may be followed by chronic inflammatory changes and the deposit of masses of urate of sodium in the cartilages and around the joints. Twinges of pain in the small joints of the hand and foot are premonitory symptoms, but an acute attack comes suddenly with extreme pain usually in the bunion joint of the big toe which swells rapidly and is hot, tense, and shiny. It

seems as if it were in a vice. The temperature may rise to 102° or 103°. Pain never goes away but is worse at night for from five to eight days, when the symptoms gradually abate. Other joints may be involved subsequently, often the corresponding toe of the other foot is. Some have three or four attacks a year, others at long intervals; with increasing frequency and with the gradual involvement of other joints, chronic gout becomes established. Deposits of urates appear in the articular cartilages, ligaments, and peri-articular tissues, and in time the joints of the feet and hands become irregular and deformed. Concretions may also be found about the elbows and knees, the tendons and bursæ; the skin may ulcerate and the chalk-stones be exposed and disintegrate. This disease is rare in America but irregular gout may be more frequent than was formerly believed to be the case; and occasionally at autopsy deposits of urate of soda are found in the joints of those who, during life, were supposed to have arthritis deformans.

This case was reported by F. L. Richardson, of Boston, in a clinical report of 75 cases of arthritis deformans (chronic non-tuberculous arthritis), which shows how closely chronic gout may resemble arthritis deformans.

A woman, white, married, 77 years old, occupation, housework, was seen at the Boston Almshouse and Hospital, at Long Island, suffering from rheumatic pain in her knees for three years, although, at times, she had had slight attacks of pain for twenty years past; she was well developed, somewhat stout, heart slightly enlarged on the right with a systolic murmur at the apex, radial artery sclerotic, no tremors, left knee stiff, unable to close the fingers tight or to completely extend them, motion at the wrist also slightly limited without deformity, pain, or tenderness, motion in right elbow slightly limited, shoulder motion considerably limited but without pain, tenderness or deformity.

There was no particular change in the patient's condition during her eight months stay, but she gradually became weaker and she died in coma.

At the post-mortem examination, the right knee showed a joint apparently normal, except that the articular cartilage on the con-

dyles of the femur showed considerable shallow pitting and over some parts which were not pitted there was an irregular deposit of chalky, white material which could be removed, leaving surfaces resembling the eroded areas above described. Similar deposits were seen on the patella and to a very slight extent on the tibia.

Microscopic examination of the deposit showed it to consist of urate crystals.

Chronic gout is little understood as it is so uncommon. Clinically it is characterized by painful and stiff joints; it makes slow progress with periods of acute exacerbations coming irregularly when new joints may be affected, or it may be confined to those previously involved.

Chronic gout seems different from acute gout; it may begin as acute gout or may follow irregular or masked gout. Gouty concretions are different from Heberden's nodes because they are attached to the soft parts and not to the bone; sinuses may form after a while leading to these tophi, and osteomyelitis may follow and destroy most of a phalanx of finger or toe slowly as the process involves little of the bone at a time, gradually extending into the shaft. Either the shaft or the ends of the phalanx may be affected first; if the latter, then the corresponding end of the adjacent bone is involved and the joint is destroyed as in the atrophic type of arthritis, but with this difference —in gout there is destructive disintegration of bone and union like a fracture and there is no atrophy of the soft parts, whereas, in atrophic arthritis, the atrophy of both the bone and soft parts is the prominent symptom, and the phalanges appear in X-ray to be crowded or telescoped together without losing the articular outlines.

Disintegrated bone is thrown off in small crumbs through sinuses from which at first pure urate of soda from the chalk-stone was discharged. During an attack, or while deposits of urates are being made about the joint, the elimination of urea by the kidneys is decreased; at other times, there may be a great excess of uric acid elimination.

Patients with chronic gout are dyspeptic and have sallow complexions; they may have arteriosclerosis with hypertrophy of the left ventricle.

**Treatment.**—But little is known about treating them. Rest in bed during an attack, and local warmth to the affected part relieves pain; sweating with rubber tissue or flannel is helpful; dyspepsia should be treated during the acute stage by a liquid or soft solid diet, and after the attack, if the digestion will stand it, forced feeding is desirable. Throughout the disease, especially during the acute stage, large quantities of water should be taken and the amount of urine should be kept large. There is no reason why meat and nitrogenous food should be excluded.

Colchicum or the salicylates may be used to cut short an attack; iodide of potassium and the benzoates have been recommended; quinine and iron as a tonic afterward; hydrotherapeutic measures, blistering, or superficial brushing with the Paquelin cautery, hot-air baking, and massage have also been tried.

## FUNCTIONAL OR HYSTERICAL JOINT DISEASE.

Functional or hysterical affections of the joints may be divided into two groups—those which are simulated, and those in which the symptoms are exaggerated,—the symptoms of a disease or injury which has been or is still present.

### SIMULATED DISTORTIONS.

The first class of cases, of course, includes the malingerer, who is rare but not unknown in childhood.

**Joint Disease.**—Attempts to simulate the limp of hip disease are usually easy to detect. There are many symptoms of hip disease besides the limp, limitation of motion due to reflex muscular spasm may be simulated but the simulation will be detected when the patient's attention is withdrawn from it; muscular atrophy is absent, hence distortion without atrophy or shortening should arouse suspicion. If the process has been one of long duration we expect, in hip disease, to find evidence of deep infiltration or commencing abscess which is not found in the hysterical, nor is shortening.

In the knee, simulated disease can be excluded often in the same

manner. Hysterical club-foot can easily be differentiated from the congenital variety but may simulate paralytic club-foot; by the history, anterior poliomyelitis, and spastic paralysis can usually be excluded, and the other nervous diseases which produce paralysis have definite symptoms. If doubt remains, the electrical reactions of the muscles are tested. Atrophy in hysterical club-foot is very slight or wanting. Cases of hysterical scoliosis have been reported. Whitman mentions one with an exaggerated lateral twist of the spine so that the shoulder approached the pelvis, the spine was flexible and straightened completely in recumbency, and complete recovery followed the settlement of a suit for damages.

**Neuromimesis.**—In the second class of functional affections of the joints, a physical basis for the symptoms is always discoverable; they are a neuromimesis. Trauma is frequently an exciting cause and the pain seems to persist indefinitely without ascertainable cause except for the patient's abnormal sensitiveness and self-concentration. They are therefore called habit pains. Slight physical abnormalities which would give no inconvenience to a normal person produce exaggerated symptoms. Careful examination usually shows the presence of neurasthenia. At other times, organic and functional diseases are present together; a joint affection, which on examination appears to be of a mild character and in the convalescent stage, is considered by the patient to be most acute and the true character of the joint can only be detected by careful and most gentle examination with the patient's attention distracted. While the symptoms of neuromimetic disease are subjective only, certain objective signs of structural trouble may be present, such as atrophy from disuse, distortions which are usually unlike those seen in disease; increased warmth over the limb may be observed and local sweating, but other physical signs of disease in the affected joints are generally absent.

**In the spine,** a sensitive, painful condition is often present as the result of a slight accident. This may persist for many months, is characterized by sensitiveness over the spinous processes of the vertebræ, pain on motion and manipulation. It is generally associated with neurasthenia. The pain and tenderness are often localized at the

base of the neck, between the shoulders, low dorsal region, the end of the spine; they are aggravated by fatigue, and are accompanied by hyperesthesia, or by burning sensations.

Patients may refuse to sit or stand because they cannot bear weight on the spine. Sometimes the back is held stiffly, except when the patient's attention is diverted. In most cases, the normal attitude in standing is really somewhat at fault; a short leg, a round, or hollow round back, or extreme lordosis is present, and the muscular development is very poor; backache of this type results sometimes from flat-foot or contracted foot; sprains of the vertebral column may cause considerable disability and persist for a long time; stiffness and pain may cause a mistaken diagnosis of Pott's disease and may also lead to a train of symptoms such as we have just described.

FIG. 149.—Hysterical scoliosis. (*Lovett.*)

**Treatment.**—It is important from the outset that the surgeon be sure of his diagnosis. A definite plan of treatment must be adhered to; at first the patient's general condition must be brought as nearly normal as possible; then the patient is to be trained to regain the use of the disabled limb or spine. Rest in recumbency part of the day must be secured in all cases in which the spine or hip is involved; careful and continuous routine exercises, careful feeding, and such medication as is necessary for the general health must be insisted upon.

The amount of attention to the local condition must be varied for different patients. An important part is the improvement of the circulation and strengthening of the surrounding muscles. Massage, local hot-air baths, electricity, gymnastic exercises, even the vibrator may be of great service. Exercise must be in graded amounts slowly increased, each advance is an important gain. The mechanical active and passive exercises when available are of great use—the appliances of Zander and others are most valuable. As a rule, mechanical apparatus like braces and splints are to be avoided but in some cases with marked muscular weakness they are temporarily useful, as in a patient with a very weak back who was much benefited by wearing a light steel brace with flexible tempered uprights. Crutches likewise are of temporary utility. For functional affections of the ankle, knee, and hip, it is sometimes advisable to remove the effect of weight-bearing by a high sole on the sound foot and the use of crutches.

In both groups of cases even if no physical cause for the disability can be found to exist, it is a mistake to belittle the symptoms or treatment. The patient's co-operation must be secured and a gradual gain, even if slight, should bring encouragement. These cases vary in difficulty and often tax the physician's ingenuity severely, but he should remember that his success depends largely upon his own judgment, and failure may leave his patient a hopeless invalid.

# PART IV.

## DEFORMITIES FROM PARALYSIS AND FROM AFFECTIONS OF THE MUSCLES.

## CHAPTER XVIII.

# DEFORMITIES FROM DISEASE OF THE NERVOUS AND MUSCULAR SYSTEMS.

## INFANTILE PARALYSIS.

Infantile paralysis; anterior poliomyelitis; acute atrophic spinal paralysis; infantile spinal palsy; infantile spinal paralysis; essential paralysis of childhood; paralysie spinale; paralysie infantile; téphromyélite; Kinderlähmung; poliomielite; mielite anteriora. It is a common disease and produces about 7 percent of all deformities.

The affection was first described in 1840, as an affection of children; though essentially a disease of childhood, Taylor, in the Out-patient Department of the Massachusetts General Hospital, found seventy-six adult cases during a period of 4½ years. It may begin in infancy as early as the twelfth day after birth; it comes both in epidemics and sporadically, Most cases appear between May and September. An epidemic was correctly observed in 1843 but for 45 years after that time its epidemic nature was forgotten.

FIG. 150.—Old infantile paralysis: back-knee and varus, walking with a crutch.

Fully two-thirds of the cases at the Children's Hospital, in Boston, fall between the ages of 6 months and 4 years, or in the period of the first dentition. It frequently comes on in a night, it attacks boys and girls, healthy and unhealthy alike. The acute onset and its occurrence in epidemics in summer, have led to a belief that

it is infectious. The infecting organism has not been demonstrated. The Weichselbaum-Jäger diplococcus of spotted fever was found in cerebrospinal fluid withdrawn by lumbar puncture on the thirteenth day of the disease by Schultze; but as paralysis attending cerebrospinal meningitis is sometimes indistinguishable from infantile paralysis, this evidence is not conclusive.

**Epidemics** have been reported by Caverly, in Rutland, Vt., Alston, in Australia, Madison Taylor, in Cherryfield, Me., J. J. Putnam, in Boston, and E. G. Brackett, in North Adams, and recent epidemics have occurred in Italy, in California, in Alabama and elsewhere.

The following cases, reported by Brackett, occurred during the summer of 1894 at North Adams, Mass. Out of several times that number affected 10 children were seen and examined and data were obtained both from the parents and the attending physicians; they had all been ill between the middle of August and the 18th of September, except a single case on the 25th of July; the invasion was sudden and sharp. Fever, headache, vomiting, delirium, or stupor, preceded by a distinct interval the advent of paralysis; in one case they were said to have preceded it 21 days; the initial fever was over 106° in 3 cases, stupor and delirium were present often; 8 out of the 10 cases lost control of the sphincters, 5 of the bladder only, 3 both of rectum and bladder, 2 of the 8 had incontinence 5 years afterward; of the 3 in whom the rectum was affected, 1 did not regain control for 15 months, another for 2 years; hyperæsthesia was found to be so marked in 5 cases, that the weight of the bedclothes could not be borne; 1 had anæsthesia, a rare condition; there was loss of speech in 2; and one was blind for two weeks. The severe nature of the attacks is readily seen from this account.

Pasteur, in 1896, reported an epidemic occurring in 7 members of the same family.

Severity is the characteristic of epidemics. Sporadic cases are milder, as both the symptoms and the extent of the paralysis are less.

**Pathology.**—The pathology of the early stages is not known. Later the gray matter and the ganglion cells of the anterior horn are involved in an interstitial inflammation and there is a resulting

degeneration of the motor or ganglion cells of the anterior cornu. It is believed the inflammation works its way in along the peri-vascular spaces around the small blood vessels in the anterior commissure of the cord. In a few autopsies the spinal meninges were inflamed. The paralysis is always flaccid and it is seldom that there are sensory disturbances, like hyperæsthesia, or paræsthesia. The anterior nerve roots may dwindle considerably in size. The paralyzed muscles are relaxed, flaccid, and much atrophied, the limb cool or cold and the foot more or less cyanotic. It is said that one can predict from its color whether there is a chance for a muscle to recover, for complete cutting off of nerve supply produces in time a fatty change in the muscular tissue so that the color becomes a pale, opaque, yellowish-white; shades from pink to red indicate a muscle less completely cut off and with greater chance of recovery. This color change is used by Hoffa as an aid in operating.

**Symptoms.**—The stage of onset is seldom seen by the orthopedic surgeon, and is often mistaken for other diseases by the physician. It may be preceded by fever, and restlessness for several days with vomiting, and in infants by convulsions or by pain in a limb; but paralysis may, however, come suddenly without premonitory symptoms and this has been called the subacute variety of poliomyelitis. The severest cases at the onset may be unconscious with frequent vomiting, with retention of urine or incontinence of both urine and fæces; and vomiting may be of the cerebral type. There often is pain in the limb before paralysis is discovered. Paralysis comes suddenly and is often paraplegic in type, although all sorts of distributions may be found; monoplegia, and paraplegia comprise three-quarters of the cases; diplegia, crossed paralysis and paralysis of the muscles of the back and abdomen are found; but hemiplegia is unusual and the respiratory muscles and those of the face are never involved.

With the advent of paralysis the prodromal symptoms subside. The paralysis attains its height in a few hours, and the stage of convalescence begins with an improvement so gradual that it is at first unnoticed. The paralysis, even at its height, affects whole groups of muscles like the extensors, adductors, and supinators. Under

improvement, certain groups show a return of strength while others do not. After six or eight months, the improvement usually comes to a standstill, but some unrecovered muscles still slowly gain, perhaps for two or three years. The unantagonized muscles pull, distort and produce both deformity and disability. When the calf muscles are paralyzed, the patient walks on his heel; when the anterior tibial group of muscles are affected, on his toes; and if the peroneal muscles are then stronger, a valgus position is added; if the peroneal muscles only are paralyzed, the position is varus.

Children may have complete flaccidity of the leg below the knee or of the entire limb, and the same is true less often of the

FIG. 151.—Paralytic valgus.

FIG. 152.—Paralytic valgus.

upper extremity. Muscular atrophy is rapid and extreme, and begins early. The bones fall behind in their normal growth, shortening always occurs, for one limb often recovers its function and grows while the other grows less fast. The paralyzed limb is cold, flabby, relaxed, and lifeless. The skin is blue from passive hyperemia and poor circulation. A third stage, the period of deformity, is not sharply defined and is marked by static paralysis and contraction distortions. It is for this that the orthopedist usually is consulted.

The deformities are due to lack of growth, or shortening, and to the effect of paralysis. Shortening of an arm is comparatively unimportant, but in the leg, if uncorrected, it may induce lateral curvature by tilting the pelvis.

Deformities due to paralysis are manifold. They seldom appear sooner than two months after the onset and usually not for many months. They have been divided into those caused by the contraction of unopposed muscles, and those due to laxity of the muscles and ligaments. Weak muscles always stretched by a stronger antagonist muscle or by the body-weight in walking can not regain strength. For this reason it is, even early in the disease essential to support and to retain the limb in normal positions, e.g., the foot at a right angle to the leg, etc.

The thigh muscles which are most affected are the internal and the anterior groups. The glutei and hamstrings are only involved in complete paralysis of the leg, *jambe de Polichinelle*. The loss of the anterior group seriously interferes with locomotion and when the child finally learns to walk, the forward step is made through the action of the sartorius and psoas muscles flinging the knee outward and upward more than forward; furthermore, there is inability to stiffen the knee and the erect position of the limb is maintained only by pressing on the front of the thigh with the hand to prevent the knee from doubling up when the weight is on it. When the entire limb is paralyzed, the psoas, unopposed, produces flexion, adduction, and rotation outward of the hip, while the knee and foot hang limp. Nature attempting to make the limbs parallel, drags and tilts the pelvis, rotates it on a transverse axis, and in time produces lateral curvature of the spine.

At the knee, contraction in the flexed position is common and is often accompanied by subluxation and by knock-knee; but if on the other hand, laxity predominates, the knee hyperextends and abnormal lateral mobility arises. Hyperextension of the knee-joint when combined with paralysis of the extensors, which lock the knee in walking, may be a good thing, as it enables the patient to walk without pressing his knee back with his hand, for the mechanics are now reversed and under loading the hyperextended knee, tries to hyperextend more instead of flexing, hyperextension being limited by the posterior ligament. Outward rotation of the tibia upon the femur is also a common occurrence.

Below the knee the anterior tibial muscles and peronei are fre-

quently involved together, resulting in a toe-drop and later in talipes equino-varus, or if the peronei be intact, equino-valgus. With a backward knee an equinus position of the foot is necessary that the toes and heel may touch the ground together. Pure flat-foot, calcaneo-valgus, and calcaneus are much favored by lax ligaments. In the two former, severe grades of flat-foot may develop from walking, and in talipes calcaneus the unsupported front of the foot drops, causing extreme hollow foot, pes cavus, not unlike the form of the foot of the Chinese lady which has been distorted by bandaging.

**The Paralytic Sequelæ.**—Deformities which may be reckoned as sequels of this paralysis are lateral curvature of the spine, and paralytic dislocations.

*Lateral curvature of the spine* results in three ways: From pelvic obliquity due to legs of unequal length; from unilateral paralysis of the muscles of the back; and from other faulty attitudes due to paralysis, e.g., paralysis of one arm, or of one serratus magnus, or one sterno-mastoid. The effect of paralysis of different muscle groups is given by Schulthess; paralysis of both sides of the back leads to carrying the head and the upper part of the trunk leaning backward so that the weight may antagonize the muscles of the front; with loss of abdominal muscles, on the contrary, one bends over, or leans forward for similar reasons; paralysis of shoulder muscles is mechanically not unlike ankylosis of the shoulder, in that the thorax tries to support and fix it; paralysis of one leg throws the body-weight over the sound hip by inclining the spine to that side and backward; just how it does this depends on the distribution or involvement of the muscles of the hip and pelvis. Paralytic curvatures are always of long radius, bad postural curvatures may arise from paralysis of the back muscles and also curves which are symmetrical and may be very disfiguring.

Schulthess and Hoffa have seen exceptional cases in which the curve in partial paralysis of the back muscles was convex toward the most paralyzed side, but as a rule the curve is convex toward the stronger side, and is especially pronounced in the sitting position. Partial paralysis of the abdominal muscles gives, as a rule, a curva-

ture convex to the weaker side, often a kypho-scoliotic curve, but the direction of the curve may be to either side. Paralysis of an arm may produce a curve in the spine, (if the deltoid and biceps are paralyzed,) which is high and convex to the side of the paralyzed arm. A similar condition is seen in obstetrical paralysis. In scoliosis from infantile paralysis of the lower limb, the shortening and the peculiar distribution of the paralysis makes it difficult or impossible to determine the mechanism by which the curve becomes a right or a left one.

*Paralytic dislocations* are uncommon accompaniments of the severe cases. The hip may dislocate spontaneously in bed or in walking; and usually the head lies on the dorsum ilii. If unreduced, the dislocated head may become firmly attached and the leg be fairly useful but short. A dislocation may be reduced after many months and reduction has occurred spontaneously. The knee-joint may be so lax that a partial dislocation takes place at each step. Subluxation of the knee is not uncommon from the unopposed pull of the hamstrings. Paralysis of the deltoid muscle may produce dislocation of the shoulder.

FIG. 153.—Paralytic equinus.

**The electrical reactions** of paralyzed muscles are usually typical by the second or third week.

The faradic irritability of muscles which are completely paralyzed may be completely lost by the second week, although in later years a trace of irritability to faradism may be found. Muscles without any faradic irritability early in the disease are almost always destined to remain paralyzed. In testing with the galvanic current, all the affected muscles respond slowly, and respond only to stronger currents than they would normally. Normally, the cathodal closing contraction should be stronger than the anodal, but in infantile paralysis, closure of the positive pole gives the greates contraction. This is the "reaction of degeneration." It requirer only a little experience to use this electrical test and to interpret it correctly. Babies and little children are so constantly active that the test is not reliable on them.

## TREATMENT OF INFANTILE PARALYSIS.

**Treatment.**—As the diagnosis is seldom made before paralysis appears, the treatment is often not what one could have wished in the early stage. Free catharsis, lying on the side or stomach, blisters and cups over the spine, the administration of ergot, the bromides, and strychnia, have been recommended. The general condition of the child should be kept as good as possible, and the fever lessened by baths.

During the stage of convalescence some of the paralysis gets well rapidly, and one should aim to maintain a normal position of the limb, to guard against overstretching the joints, ligaments, and muscles. The nutrition of the paralyzed muscles should be encouraged by daily faradism, massage, and exercises.

FIG. 154.—Paralytic calcaneo-valgus.

The feet should be kept at right angles to the leg and the weight of the bedclothes be removed. As the circulation is feeble, straps and bandages are to be avoided as much as possible.

Electricity may be begun as early as the end of the first week; a gentle galvanic current through the affected muscles and nerves at first, later, those muscles which contract feebly to faradism should be stimulated, and those which do not respond to faradism can be exercised by the interrupted galvanic current. Dry warmth and rubbing are very important, and anything which stimulates the circulation, like dry heat, helps nourish the muscle. Skilled massage is probably better than the mother's rubbing, but the latter should not be discouraged, for rubbing is a good part of the treatment. Active exercise is also essential but the muscles must not be tired. Exercises should be graded carefully for each child and at first moving the limb with the hand should aim to assist the weak muscles to use any power they may have, and there should be exercises whenever the rubbing or massage is given.

**Mechanical Treatment.**—This treatment aims (1) to restore locomotion, (2) to antagonize distortions and maintain correct position by supporting the joints in normal positions, and by preventing displacements to make walking possible; it may also overcome deformities already present. Obviously, no special form of apparatus can suit the individual peculiarity of each case; all sorts of modifications of apparatus are to be used, one should not be limited to a few appliances, but rather use his ingenuity in devising whatever is best for each individual patient. It is always better in the stage of deformity to have the patient walk on his foot,—not use an apparatus which allows walking with the foot kept off the ground.

To control simple talipes calcaneus, a single side upright extending to a hand's breadth below the knee may be attached to the sole of the boot with an ankle-joint stop to prevent dorsal flexion but allow free plantar motion; and it is better to insert a plate between the leathers of the sole to prevent its bending.

FIG. 155.—Paralytic calcaneo-valgus. (*Children's Hospital.*)

For equinus the apparatus figured in Chapter XXI, page 383, may be used with either single or double upright and the same may be modified for calcaneus. See Chapter XXI, page 383.

The equino-varus position which is more common may be supported by the apparatus for club-foot (Chapter XXI, page 383), and for valgus the apparatus shown in Chapter XXI, page 382. If needed these supports for the ankle and sole may be incorporated into a longer splint to control the knee or hip. Pes cavus may be treated by inserting a thin steel between the leathers of the sole of the boot with an extra strap buckling the instep down on to it. Fasciotomy of the plantar fascia is often desirable.

When the muscles of the thigh are strong it is not necessary to prolong the upright above the knee. Appliances should be as light as possible on account of weakness of the leg. When

the quadriceps is paralized, the knee doubles forward when weight is borne upon it, and to make locomotion possible it is only necessary to prevent the knee from bending forward. A simple way to prevent this is shown in Chapter XXI, page 375.

Leather lacings may be added to the apparatus, which by covering a large area of skin, substitute surface for localized pressure. Should the knee hyperextend, a broad leather strap passing behind the knee will correct this. More complicated splints, hinged at the knee for convenience in sitting may be seen in Chapter XXI, page 381.

When paralysis is extensive a limited degree of locomotion is given by attaching the upright above the hip to a leather jacket; a caliper knee splint may be used, jointing the outside upright at the trochanters.

The muscles of the back are seldom paralyzed without paralysis of the leg, and complete paralysis of the back is disabling. Partial paralysis may be helped by the use of a leather jacket, a spinal brace, or corset, which connects with leg splints to make standing and walking possible.

It is difficult to control paralysis of the abdominal muscles which produces great lordosis in standing. A waist band or corset may be tried.

**Appliances to Correct Distortions.**—Mechanical treatment may be used to correct flexions and distortions of the joints, although these are better remedied by surgical means.

Flexion of the hips is hard to correct by mechanical means because it is so hard to fix the pelvis. Two caliper splints (Chapter XXI, page 375) are attached to a leather jacket by side irons hinged over the trochanters. Bending forward is then limited by straps from the knees which are buckled to the back of the jacket while the child walks about on crutches. Flexion of the knee may be straightened by bandaging the leg to a splint (Chapter XXI, page 373) in the following manner: the bandage is applied under one upright over the thigh, under the other upright and over the thigh, and so on, until the knee is covered where it is firmly fixed. If there is a tendency to subluxation the head of the tibia should be forced forward

by a leather strap between the uprights immediately behind it. Walking is then encouraged. If the deformity is severe, however, the patient should be confined to bed and traction by weight and pulleys should be made as seen in Figure 134, page 257.

A leather knee-cap on a caliper splint may slowly straighten flexion of the knee, or a turn buckle may be applied as recommended by Eliot to a hinged knee splint or the Shaffer's splint, or it may be corrected by weekly applications of plaster bandage with the knee extended each time as much as possible.

The mechanical correction of deformities of the foot is tedious and operative measures are to be preferred. Corrective plaster-of-Paris bandages applied under anæsthesia are of benefit. The walking appliances used for the various forms of talipes are modified to suit the requirements of each individual.

**Operative Treatment.**—Three different objects are to be attained by operative measures for infantile paralysis deformities: (1) the correction of deformities; (2), muscle transference, or the application of the power left in the leg in a more serviceable direction, and (3), nerve grafting to cause a return of nerve power to some of the paralysed muscles.

The deformity from infantile paralysis which one has to correct is usually a flexed hip, a flexed or subluxated knee, usually combined with knock-knee and paralytic talipes. Most of these conditions may be overcome by forcible manipulative correction under ether, with tenotomies, fasciotomies, and fixation in plaster bandages.

Subluxation of the knee may be reduced by the method of Whitman or by ordinary manipulation. The genuclast is seldom necessary. See chapter XVI, p. 258.

Resistant flexion of the hip usually requires an open incision to divide the contracted fascia lata which is not involved alone, but there are intra-muscular partitions which need division too. Osteotomies for knock-knee or even excision of the knee may be necessary in rare cases.

These measures do not restore mechanical force, they only assist the mechanics of locomotion. Arthrodesis of the ankle-joint and resection of the knee are also done to obtain stiff joints in a

useful position to walk on in cases of complete paralysis with flail joints.

The writer knows of one patient, a woman in middle life, who as a young girl of sixteen had the left ankle and knee-joint resected. She is well, has a useful limb, though slightly lame.

**Arthrodesis of the Ankle.**—Arthrodesis of the ankle-joint is often done for flail-ankle to obviate the irksomeness of wearing apparatus for life. Of several different methods, that of Kocher offers the best view of the joint. Under full anæsthesia, a semi-circular incision is made around the external malleolus, the tendons of the peroneus longus and the peroneus brevis are found and divided between two silk guide stitches; the external ligaments of the ankle are divided and the foot supinated inward while any remaining attachments of the capsule anteriorly and posteriorly are cut to allow complete dislocation inward. With chisel and knife every vestige of articular cartilage is pared away from all the surfaces of the joint, tibia, malleoli, trochlear surface and sides of astragalus. The joint is then replaced, the external lateral ligaments sutured, the peroneal tendons united by their silk guides and the wound sutured, dressed and encased in a plaster-of-Paris bandage, taking care that a serviceable position of the foot is maintained in plaster. After-treatment demands three months with the foot in plaster, and during this time crutches should be used and the foot swing free of the ground. This should be followed by walking on a stiff-ankled supportive apparatus (see Chapter XXI, page 376); daily massage and the use of the support should be continued six months.

Dane found the results following this operation at the Children's Hospital, in Boston, far more serviceable than those following tendon transference. Townsend, at the Hospital for Ruptured and Cripples, in New York, concludes that the relapses after arthrodesis for paralytic club-foot properly performed are less frequent than after tendon transplantation. Bony anklyosis is not essential in young chlidren and is not often obtained. Hertz, of Aukland, New Zealand, nails the astragulus to the external malleolus and the calcaneus to the astragalus by silver staples after doing arthrodesis to secure firmer union. The staples are left in situ.

**Tendon Transference.**—Tendon anastomosis or suture had been done in wounds severing the forearm tendons since 1780, when Nicoladoni, a hundred years later, used it to ameliorate paralysis. It was only some thirteen years later that the value of this operation began to be known.

Tendon transferences may be done in several ways; either a strong muscle may be made to pull a paralyzed tendon or it may be shifted to a new bony attachment; in the first case a sound muscle may be divided and the tendon of a paralysed one attached to it, or a paralysed muscle may be divided and the tendon attached to a sound muscle nearby, or a sound tendon may be split and part transferred to a paralyzed tendon; in the other case the whole or a part of the tendon of a sound, strong muscle may be transplanted into a new attachment made into or beneath the periosteum. This second method, devised in 1900 by Lange, of Munich, transfers the attachment of a strong tendon to a new locality, and is of great use in the foot as it is possible almost always to find some new point of attachment which will be effective; the chief drawback is the insufficient length of many tendons, a difficulty which may be remedied by piecing out the tendon with several strands of stout silk.

As Lange points out, much depends upon the amount of strength remaining in the transferred muscle. In his operation, besides the strength remaining in the muscle, much depends upon fixing it in such a new place that it pulls to greatest advantage; in other words, it should be attached at a point where it gives on contraction the required motion. Lange also showed that when the tendon is not long enough strands of braided silk quilted into the end of the tendon and attached into or beneath the periosteum may be employed, and he has shown that fibrous tissue forms about the strands and between the fibres of the silk, converting it practically into new tendon. The silk should be boiled in 1-5000 corrosive sublimate solution.

It is better to make the limb bloodless before operating. The incisions, the points of insertion, and the tendons employed must vary according to circumstances.

In transplanting tendons into the periosteum a more solid attachment may be secured by dividing the periosteum with a chisel, lifting a small bony flap on each side, stitching the tendon into the gap, and the periosteal flaps over it. Mutter does still more. He bores through the bone, passes his tendon through the hole, loops it back on itself and stitches it tight.

**Tendon Shortening.**—Hoffa, in addition, does much for the correction of paralysis by shortening or lengthening the tendons of muscles which are paralyzed or paretic. In order to determine whether they are paretic or completely paralyzed, he makes an exploratory incision over the belly of the muscle to see its color; pink and pale reddish muscles are paretic, yellow and white ones are hopelessly degenerated. He shortens the tendon by taking a tuck in the following manner:

He lifts the tendon on a director approximating the points of insertion and origin as much as possible and quilts a strong silk suture above and below into the tendon he thinks two points can be approximated; the ends are tied together and then tied around the loop of tendon which is held up on the director. Then this loop can either be cut away or stitched to the tendon above or below.

Tendon lengthening can be done either by a simple tenotomy; by the operation of splitting the tendon in two lengthwise, dividing each half at a different level and stitching them together; or the Z-shaped tenotomy may be done according to the method of Bayer, which means dividing a little more than the right half of the tendon at one point, and the left-hand half considerably higher up, and forcibly stretching until the fibres slip by each other. In order to obtain more width after splitting the tendon, Vulpius splits it parallel to the skin instead of at right angles to it.

Many different forms of quilting sutures have been used in suturing tendon to tendon. They have met with some success but the final results of simple tendon anastomosis are generally unsatisfactory in children, for either they come apart, or the piece of paralyzed tendon stretches, or the old tendon forms anew and takes the strain off the work.

David Silver, of Pittsburg, in an experimental study of the effects of sutures in the tendons of animals, finds that the suture maintains

apposition of two tendons during repair without exerting sufficient tension to produce necrosis, in fact that it is hard to tie a suture tight enough to cause tendon necrosis. Union begins in about five weeks, for the stitches suffer constant strain, partly from normal muscle tone and partly from involuntary contractions, because the tension at the time of operation has to be high. Tendons have a meagre blood supply and many relapses are due to tearing out of a suture. The high degree of quilting or interweaving of suture and tendon, advocated by Lange, does not appear to cause necrosis.

A tendon's blood supply is from two sources: from the belly and bone insertion of the tendon, and from the sheath; for this reason the sheath should be replaced about a tendon after operation.

Hoffa found the process of repair still in progress 242 days after operation, which shows that owing to poor blood supply, tendons unite very slowly, true repair beginning only four or five weeks after operation and continuing for 8 or 9 months. Silver believes that failure through insufficient hold of the suture in the tendon is common, but from overtight suture it is very rare; that the process of repair is slower in a transplanted than in one sutured after a wound, probably because the circulation of the reinforced tendon is disturbed by separating it from its surrounding tissues; and owing to defects in the synovial sheath.

Silver's experimental work throws a more favorable light upon Nicoladoni's method of suturing two tendons, but emphasizes the importance of restraint and fixation for many months after operation. To accomplish this without joint stiffness gentle massage and exercise are to be employed daily.

Before operating, the surgeon should map out exactly what he means to do. There are different ways of making that paralyzed limb useful, and a combination of methods, muscle transference, muscle lengthening, and muscle shortening should all be considered. It is essential to know whether muscles are *paralyzed or paretic*, for paretic muscles stretched for months by strong antagonizing ones seem unable to contract. Electric stimulation should be tried, and if that fails an exploratory incision over the belly of the muscle to see its color.

Schantz holds that there are a few definite points on the foot for the proper application of muscular force from the leg. That for a simple equinus, an insertion should be made on the front of the foot, on both sides; for an equino-varus, on the outside of the foot; and for valgus on the inner side, and he tries by long incisions to get the tendon in a straight line from its origin to insertion. He believes the power-giving muscle should never be severed from its old attachment, a slip may be taken from it to establish a new one. For suture he uses an aluminum-bronze wire which later he found covered with tendinous tissue; the superficial wound should be closed tightly.

A list of the principal transplantations combined with muscle shortening and lengthening for different paralytic deformities of the foot follows:

*For paralytic equinus.* Lengthening of the tendo Achillis with shortening of all the anterior tibial group of muscles.

*For paralytic equino-varus.* A slip for re-enforcing is prepared from the outer border of the tendo Achillis which is then lengthened; the anterior tibial group of muscles are shortened, the peroneus longus and brevis are shortened and the slip from the tendo Achillis brought over and transplanted into them.

*For paralytic valgus.* Shortening of the tibialis anticus tendon and transplantation of the extensor longus hallucis tendon into the scaphoid near the anticus insertion, with lengthening of the peroneals; or Lange's transference of the peroneus longus tendon to an attachment on the inner side of the calcis.

*For paralytic calcaneus.* Shortening of the tendo Achillis (Willet's operation) with transference of the peroneal tendons and part of the extensor crommunis digitorum into the insertion of the tendo Achillis.

Lange uses artificial silk tendons attached to the periostum directly; for instance, in order to secure a straight position of the foot in paralytic equino-varus, where the tibialis anticus is the only strong muscle, he splits its tendon and attaches the outer half to the periosteum of the base of the fifth metatarsal bone.

**To restore extension to the knee** from paralysis of the quadriceps

muscle the sartorius is transplanted into a slit in the quadriceps tendon at the upper border of the patella, or either the biceps or the ilio-tibial band preferably the biceps, may be transplanted into the same attachment; but Lange instead brings forward the biceps and semitendinosus tendons which are too short to be planted into the patella, so he lengthens the tendons with four stout silk strands and sews the ends of these strands into the side of the patella and also into the periosteum of the tibial tubercle. Gluck, in 1892, and Kümmel, in 1896, had pieced out tendons with silk. Believing that necrosis of a tendon is very rare, he stretches the tendon as tight as possible in suturing.

**Tendon Transference in the Arm.**—Tendon transplantations have been of benefit in paralysis of the upper extremity. Tubby transplanted long strips from the outer head of the triceps into the biceps tendon, close to its insertion in the radius to restore flexion at the elbow. Efforts to restore the deltoid by transplanting the whole of the clavicular portion of the pectoralis major and part of the trapezius into the deltoid's insertion, have been made both by Tubby in England and Soutter in this country. The angel wing deformity from paralysis of the serratus magnus has been cured by transplanting the lower part of the pectoralis major into the serratus magnus. Wrist-drop has been improved by Robert Jones and others by transplanting active carpal flexors into paralyzed extensors and this operation is done for spastic paralysis also. Tubby converted the pronator radii teres into a supinator by detaching its tendon insertion from the radius, passing it through the interosseous membrane and refixing it on the outer side of the supinated radius, an operation which has been successfully repeated by Bradford and others. When the muscle was too short, Tubby grafted the central end of the pronator radii teres into the flexor carpi radialis, bringing that tendon through the interosseous membrane after dividing it, and fixing it to the outer border of the radius.

Townsend reported seventeen cases of tendon transplantation in the forearm, and says that paralytic wrist-drop after cerebrospinal meningitis can be cured, if a new muscle plan be properly

worked out, as extensor muscles may be transplanted into paralyzed tendons and *vice versa*. The after-training is very important, and requires many months of careful work. As in the leg, tendon graftings are useless in flail joints from complete paralysis.

**Tenodesis.**—Hoffa found that he could fix a flail-like ankle by shortening all the muscles on both sides of the joint in the manner described on p. 316. This method, called by Reiner tenodesis, is available also to prevent toe-drop where there is little power left on the extensor side and as an accessory in tendon transferences. Through a vertical incision at the junction of the middle and lower thirds of the leg the tendon of the tibialis anticus is found and shortened in the usual manner; then a stout silk is sewed into the periosteum of the tibia or fastened through a small hole drilled in the bone and tied to the suture which makes the tuck in the tendon; the same is done to the other tendons fastening them to the fibula. The term tenodesis is used to mean fixation of a joint by shortened tendons, as arthrodesis means fixation by bony union.

Shortening of ligaments may be done to compensate for the over-stretching from misapplied weight. It has been little used and usually silk strands have been tied through holes drilled in the bones, which are apt to fret out or wear through in a year; shortening by quilting stitches may be tried, for even a temporary gain is worth while.

## NERVE GRAFTING.

Nerve anastomosis and transplantation have been attracting more and more the attention of surgeons for the past few years, but although a number of successful and partly successful results have been reported, the operation is not yet in common use.

In 1897, Sick and Sänger transplanted the distal stump of a paralyzed musculo-spiral nerve into the neighboring intact median nerve, and obtained a good result. Fauré and Furet, in the following year, sutured part of the spinal accessory nerve into the divided facial nerve, which was paralyzed, without improvement.

Harvey Cushing, five years later, transplanted the proximal stem of the divided spinal accessory into the distal end of the paralyzed

facial with success, and numerous experiments of nerve transference were made on dogs, showing that control and coordination, as well as power, were restored.

Spitzy, from experimental studies on animals, believes that the best method is to split off a part of an intact nerve, to implant it into a longitudinal slit in the paralyzed nerve and fix it there; he calls this a central transplantation; or else he cuts off a paralyzed nerve and plants the peripheral end into a longitudinal slit in the intact nerve, a peripheral transplantation.

If he suspects that some of the paralyzed nerve may still be active, the central end too may be put into the intact nerve higher up. The first method, central implantation, is to be used, if an intact nerve is at hand whose muscles are not important to locomotion; the peripheral method if only large nerves of equal importance to locomotion can be grafted together.

Peckham, of Providence, in 1900, restored power to the extensor muscles of the foot by transplanting two branches from the internal popliteal nerve into the external popliteal. Both patients had paralysis of the peroneal muscles. In one improvement began two or three months after operation and was much greater after a year.

The second case, an adult with infantile paralysis from childhood, had a fairly good return of power in the peronei three months after operation.

Young, of Philadelphia, operated, in 1902, for paralysis of the tibialis anticus muscle and the child had considerable return of power eighteen months later. Dr. R. T. Taylor, of Baltimore, had improvement in three cases. Tubby, in two cases of talipes calcaneus, and two of paralytic equino-varus, reported favorable results in two of the four. Excellent results have followed the application of this method to the treatment of facial paralysis. Unfortunately, one does not often find motor nerves, which can be utilized, lying close to paralyzed ones. A portion of the spinal accessory has been used to vitalize the paralyzed facial with success; the hypoglossal has been planted into the facial with success; portions of the external popliteal into the internal popliteal and *vice versa;* the musculo-cutaneous nerve into the peroneal or the muscular branches of the peroneal

into the musculo-cutaneous nerve in the leg; in the elbow, the radial and median nerves may be grafted and in the brachial plexus, the nerve trunks and cords. Nerve graftings have only been attempted in a few localities.

Sherren collected twenty-five examples of nerve sutures and graftings, in twelve of which sufficient time had elapsed for recovery of motion to take place; of these only two were failures, some improvement taking place in all of the others.

Nerve grafting and sutures in the brachial plexus for obstetrical paralysis have been noted in Chapter VI, page 80.

Thorburn reports a case of secondary suture of the whole brachial plexus seven months after an injury, resulting in partial return of strength. Sherren did suture of the upper and middle trunks of the plexus, nine weeks after division; no improvement in sensation was noticed one hundred and eighty-two weeks after, but full voluntary power had returned in the biceps. Not until three hundred and thirty-three weeks after did the paralyzed muscles react to faradism.

Spitzy, from dissections on the cadaver, finds that a branch from the obturator nerve which supplies the pectineus and gracilis is easy to find and may be passed through a canal made under the fascia, and grafted into the anterior crural nerve, near Poupart's ligament. This might restore the innervation of the quadriceps.

## CHAPTER XIX.

# DEFORMITIES FROM DISEASE OF MUSCLE.

## TORTICOLLIS.

Torticollis, or wry-neck is neither common nor rare. It appears in the clinic about once to ten club-feet and one-fifth of these wry-necks are congenital. It is confusing only because the deformity may be produced by such different causes, and so it is spoken of as congenital or acquired, true or symptomatic, reflex, and spasmodic, all terms which are rather vague.

**Congenital torticollis** has a short sterno-mastoid muscle which is usually the result of fetal myositis; although the association of other malformations suggested another explanation for the condition, microscopic study of sections of the muscle removed at operation by Kirmisson showed a transformation into fibrous tissue of the posterior part of the muscle, a scarring from inflammation which adhered to the muscle sheath. One sterno-mastoid is affected, very rarely both. From this shortening malposition of the head arises, the face turns toward the unshortened side and the chin tips that way, too, so that a prolonged median axis of the head would pass through the breast on that side, while the ear is low on the side that is shortened. The face, in fact the whole half head, is small on the side of the contraction, the skull shows it and there may be structural scoliotic deformity of the cervical spine and sometimes a double curve.

**Spasmodic torticollis** is something quite different, the usual position of the head is that of wry-neck, but it is continually jerked aside by spasmodic contractions which are uncontrollable. Its cause is unknown, perhaps some minute irritating lesion of the cortex of the brain as yet undiscovered; it follows some infectious diseases like typhoid fever and I have seen it in a case of chronic lead poisoning.

Controlling the movements of the head in an apparatus has been

of benefit and is reported to have cured. A patient of Dr. Hall, of Marblehead, could stop the jerky movements by pressing on the back of the neck with his hand, and a light steel spring clasping the posterior two-thirds of the neck, sufficed to control it. Others are most rebellious to treatment. Excision of the spinal accessory nerve which supplies the trapezius has given relief occasionally; other nerves have also been excised without benefit.

Roswell Park had a patient with aggravated spasmodic torticollis, an adult, in whom the jerky movements were entirely cured

FIG. 156. — Congenital torticollis, left sterno-mastoid contracted. (*Children's Hospital.*)

FIG. 157.—Congenital torticollis. Features of left side of face small. (*Children's Hospital.*)

after the excision of two inches from the sterno-mastoid and the removal of a large triangular section from the cervical portion of the trapezius and the much thickened omo-hyoid. Many bands of connective tissue were cut or stretched—in fact, the operation consisted in open division of everything in the neck which resisted stretching from immediately above the clavicle to the occiput.

The other forms do not have jerky movements.

**Symptomatic torticollis** means that the deformity has arisen as a symptom of caries of the spine with the spasm in the posterior

neck muscles, or of cervical adenitis. Traction in bed is to be used in cervical caries to diminish the deformity.

**False or transitory torticollis** is a transient form formerly considered rheumatic; they are frequently due to a slight adenitis or even sore throat and subside under a few days in bed.

**Dermatogenous wry-neck** arises from the contraction of large scars and is to be cured by plastic operations transplanting skin flaps.

**Acquired torticollis** includes those which come without known cause and those due to faulty use of the eyes or ears as in deafness in one ear.

**Diagnosis** is easy when one is on the watch for this deformity, but sometimes the children's parents cannot be made to notice it; facial asymmetry is less easy to detect—the line of the nose is not exactly at right angles to a line connecting the pupils of the eyes, the corners of eyes and mouth are closer together on the cheek which is less prominent, and all the features are a little smaller on that side. The skull is altered; one side of the alveolar arch may be a little smaller both in the upper and lower jaw, and the whole skull shows a twisted growth of the bones of the face, as if nature were trying to make the crooked features straight. This is plainly seen in several skulls in the Warren Museum. See Chapter VII, page 85.

**Treatment** is directed to lengthening the shortened muscle which is usually the sterno-mastoid muscle. It may be stretched or cut; and slow stretching by apparatus has been used, but the writer has had no experience with it.

*Stretching.*—Slow manual stretching by the mother three or four times a day has been successful in some babies. Rapid complete stretching under full anesthesia is done by Lorenz, of Vienna, and by Wilson, of Philadelphia. The overcorrected position is maintained for many months, at first in plaster, later in an apparatus.

This method has the advantage of leaving no scar; after-treatment should include exercises and massage for six months.

The operator grasps the etherized patient's head with both hands, turning the chin with force till it points to the shoulder of the affected side, which renders the muscle very tense, and under massage it

is felt to yield. If the contracted muscle cannot be elongated sufficiently, still more forcible massage is used, kneading and hacking at the muscle close to its clavicular end until resistance to passive motion is overcome, then it is fixed in a plaster helmet jacket applied in extreme overcorrection with the face, ears, and the top of the head left uncovered.

*Open division of the Sterno-mastoid.*—The usual incision is one parallel with the clavicle, a finger's breadth above it over the sternal and clavicular heads of the short muscle. As a preliminary, the position of the external and the anterior jugular veins should be verified by compressing them under the finger at the center of the clavicle and over the sternal notch.

Dividing the skin, the superficial and part of the deep cervical fascia, the sternal head is exposed, freed from its sheath, a director passed beneath it, and it is cut across with a knife; the upper end snaps back, but often only a half inch or less because its strong fibrous sheath, still undivided behind, adheres to the deep layer of cervical fascia attached to the sternum. Division of this sheath and fascia has to be done with great care for it is in immediate contact with the internal jugular vein, which is much widened at this point. After completely dividing this fascia one turns the head to see if division of the clavicular attachment is also necessary. It may be left if the head can be overcorrected easily, but it usually requires division in the same manner and with the same precautions as the sternal head.

An aseptic operation and a clean view of the field is essential; one should stop each bleeding point immediately so as to recognize each structure as it presents. The skin and the superficial fascia may be sewed with a subcutaneous catgut suture, and the wound dressed with a small sterile dressing fastened with flexible collodion. To avoid a depressed scar, and at the same time to seal off the deep wound, it is a good plan to have the skin drawn firmly upward before incising, so that when the suture is applied, the wound lies at the lower border of the clavicle, whose shadow partially conceals it.

*Lange's Operation.*—Lange, of Munich, divides the insertion of the sterno-mastoid into the skull at the mastoid process and the outer

part of the superior curved line of the occipital bone because the wound is smaller and is concealed by the hair. In rare instances other muscles, like the scalenus anticus and the splenius capitis, need dividing, but they can at times be stretched. Thorough stretching should always be given after division and before applying a plaster bandage. Real shortening of the trapezius is rare; and contraction or spasm of the muscles of the back of the neck is a signal to look out for cervical caries, although it may also arise from adenitis secondary to pediculosis capitis. After operation the head should be secured immediately in a plaster-of-Paris bandage in over-corrected position. This bandage should include the chest above the ensiform cartilage, the neck, chin, occiput, temples, and forehead.

Still under ether, the little patient sits on a low stool, with the head supported by two loops of flannel passing under the chin and occiput firmly held by the hand of an assistant. The entire area to be covered by plaster is protected by cotton batting with thin felt over the prominent bony parts. The plaster bandages are immersed and quickly applied to the chest, shoulders and neck, taking care when the head piece is added to get correction, that is, the greatest possible separation behind the divided ends of the muscle. In trimming the plaster, it is essential to leave sufficient space in front of the chin and over the eyes, to leave the ears uncovered, and allow plenty of room about the axillæ and shoulders. It should not be uncomfortable, as it is to be worn six or eight weeks, followed by apparatus which is light and less unsightly for going to school and has the advantage of being removable. For description of apparatus see Chapter XXI, page 356; the brace, also exercises for the neck and shoulders should be used daily and the brace should be worn at all times of the day except when exercising; at night it is unnecessary.

## MYOSITIS OSSIFICANS.

Anomalous sessamoid bones are often found in normal tendons. Other bone formations in muscles have been described as myositis ossificans. They are of two types: the first, characterized by the ossification in succession of various muscles all over the body, is of

unknown cause and is called myositis ossificans progressiva; the second type is a local condition due to long continued irritation, to excessive use, or to injury—the so-called rider's, fencer's and dancer's bones belong in this category. This bone formation is limited to the muscle in which it is situated. The traumatic type comprises those due to injury and they are generally associated with traumatic bone tumors, osteomata growing from bone.

Theories have been advanced but the method of formation is unknown. They are not formed out of effused blood nor are they aberrant sesamoid bones. They may be due to the growth of included fetal tissue; some pathologists consider them the results of inflammatory changes in intermuscular connective tissue, and Grawitz and Salmon on clinical and microscopical grounds believe the bone arises from cloudy degeneration of muscle fibres, with a small celled infiltration of the connective tissue.

In some instances no inflammatory changes are found. Robert Jones believes that it may then be caused by the detachment of small bits of periosteum; as similar growths have been produced in rabbits by Berthier who detached small portions of periosteum and the muscle insertions and stimulated the muscle with electricity.

The bone patches consist of soft cancellous bone with large marrow spaces filled with blood corpuscles and some giant cells.

In life traumatic myositis ossificans may be suspected after dislocation of a joint like the elbow if, in spite of good treatment and apparent cure, a gradually diminishing range of motion develops. The presence of hard tissue near the joint makes the diagnosis clear; but Robert Jones emphasizes the fact that these symptoms are exactly those which convince a surgeon that he has mistaken an obscure fracture for a simple dislocation, and is at last recognizing it by its large callus.

Out of a total of 339 cases of the traumatic type, the great bulk of them were found in young men fom twenty to twenty-five years.

Sometimes they adhere to the bone, sometimes they are free in the muscle; they are more common in the lower limbs than in the upper; only a small proportion are found in women.

Treatment consists in removing the bony deposits if they give

any trouble. The X-ray should guide us both in diagnosis and at operation. Complete removal of the bone should be aimed at, for if any is left it will grow. When attached to bone, it is necessary to chisel well into the shaft to avoid regrowth. No more definite rules of operation can be laid down, as it may grow anywhere. After the operation, absolute rest is enjoined for two or three weeks, and early passive motions are avoided.

## CHAPTER XX.

## PLASTER-OF-PARIS.

It is important for the orthopedic surgeon to fit and adjust his own apparatus and in exceptional cases to make it himself; especially those whose patients are in the country and in towns where of instrument makers there are none.

General practitioners may often do much for orthopedic patients by means of the plaster bandage and plaster casts They should be familiar with the technique of plaster work. One of the essentials to success lies in using the proper materials for making the plaster bandage.

**Bandage Cloth.**—Starch stiffened crinoline gauze is the best material and it may be procured in many varieties; a gauze running 30 threads to an inch is the best for plaster bandages. Crinoline gauze is sized often with dextrin or glue which retards the setting time of the bandage or prevents it. To determine between the dextrin and starch sizing the iodine test may be found convenient; or a piece of gauze may be chewed for the taste of dextrin may be recognized easily. A small amount of dextrin, a one percent solution, prolongs the time of setting, with larger amounts, the plaster fails to set. Starch contained in the bandage has no effect on the setting time of the plaster, and tends, perhaps, to increase its tensile strength. A good starch sized crinoline at present on the market is the ''Vigilant'' which comes by the piece, 30 inches wide and 24 yards long.

**Plaster.**—Plaster-of-Paris is chemically a native sulphate of lime, called, in the crude state, gypsum. It is prepared for use by pulverizing finely and calcining in ovens at a temperature between 300 and 350° F. which drives off its water of crystallization. Properly burned plaster when mixed with water recrystallizes or sets into a solid mass. A plaster bandage practically sets without expan-

sion or shrinkage because the plaster tends slightly to expand and the cloth to shrink. It really expands a trifle in setting (one percent). Two sorts of plaster are in use in orthopedic work, a quick setting fine plaster, known as dental plaster, and commercial plaster which is coarser and sets more slowly. Either may be used for casts but only the fine dental plaster for bandages. During the setting latent heat is set free, it becomes warm; this indicates that the chemical process has begun and is a signal not to disturb the bandage for fear of interfering with its set. The addition of salt, alum, or sulphate of potash to the water accelerates the time of setting but lessens its strength and durability; one-twentieth part by volume of Portland cement makes the setting quicker and increases the durability and strength.

**Preparation of the Bandage.**—There is no better way of preparing plaster bandages than by hand. Strips of crinoline 4 yards long and of the required width ($2\frac{1}{2}$–4 inches), are loosely rolled and placed upon a smooth surface and with semicircular motion dry plaster is rubbed into the meshes. After 12 or 15 inches of crinoline have been rubbed full of dry plaster it is rolled up and the adjoining portion of the gauze has plaster rubbed in; this is repeated until the entire bandage has been rubbed full of dry plaster. Plaster bandages should be kept in a dry place, preferably in wooden boxes.

R. O. Meisenbach, of Buffalo, to whom I am indebted for many valuable suggestions, has added greatly to the strength and durability of his bandages by mixing with his plasters one-twentieth part by bulk of Portland cement. Owing to increased resistance to both crushing and tearing, these bandages are applied thinner than ordinary plaster bandages.

**The Application of the Bandage.**—The part of the body to receive the bandage is first protected by a layer of stockinette or by strips of sheet cotton batting bandaged on. Protection may be very thin if one expects no swelling to occur; but when swelling is expected or when the bony prominences are very marked, this protective padding must be very thick to guard against pressure sores—for instance, for a plaster jacket it is not necessary to wind the body in sheet wadding; an undershirt or stockinette with felt pads over bony prominences

suffices; but if the bandage is applied after a forcible correction of club-foot, the cotton padding must be very thick and soft.

Having selected the proper bandages for use they should be laid horizontally in a pail full of water about 70° F., not stood upon end lest the plaster powder settle to one end of the bandage. When the bubbles cease to rise it is taken out, grasped at each end with the hands, and squeezed so that no plaster can escape. To insure a homogeneous set of the entire dressing, Meisenbach has each bandage wrung a little dryer than the preceding. In applying, the bandages should be unrolled a foot or more, wound about the part with even pressure, and each layer should be thoroughly rubbed with the hand as it is applied. Speed in application is important that the whole dressing may be finished before setting takes place. After the last bandage is applied no more plaster paste or water should be added. Smoothness may be attained by rubbing for a few seconds with a towel. The number of bandages depends on the nature of the part and the age of the patient; roughly speaking eight or ten layers are sufficient excepting over the hip and knee. The plaster bandage turned upon itself may be used to reinforce weak places, or a strip of wood or metal may be incorporated between the layers of plaster. After setting has once begun the limb must be held motionless until the process is completed, a period of about seven minutes. Rubber gloves may be used to protect the hands. The edges of the plaster are trimmed with a knife and finished by turning down over the outside of the bandage a half-inch of the material used to protect the skin.

**Width of Bandages.**—For the legs and for plaster jackets the bandages should be from 3 to 4 inches wide and 4 yards long, and should weigh 6 or 7 ounces with the plaster rubbed in. For babies with club-feet 2 inch bandages should be used and the length should not exceed 3 yards. In order to facilitate soaking up water, the bandage should be rolled on a lead pencil or a round stick which is withdrawn leaving a hole in the middle; all bandages are to be rolled loosely to facilitate quick penetration of water.

If it is impossible to obtain crinoline gauze stiffened with starch, the dextrin sized gauze may be soaked and washed so as to remove

the sizing; but this washed material wrinkles, is more difficult to cut and tear and receives the powdered plaster less readily.

**Removal of the Plaster Bandage.**—When it is desirable to inspect the position of a limb encased in plaster within a few days of its application it is advisable to bivalve the plaster soon after setting, that is to cut through the plaster with a knife on either side of the leg so as to divide it into two pieces; a wet gauze bandage is then applied tightly around the plaster which by its shrinkage holds the two pieces firmly together. To remove a plaster which has not been bivalved, the plaster should be moistened where the cut is to be made by means of a medicine dropper or coarse camel's-hair brush with either water or weak acetic acid, and the wet place is cut through with a sharp knife. Many saws, knives, and shears have been devised to cut plaster. A short-bladed knife set in a stout round wooden bandle is convenient. Care must be used not to cut the patient's skin.

After applying a plaster jacket, if it is tight and there may be little room for respiration, it should be cut down the front immediately and bandaged together with a cloth bandage so that it may be sprung open in case of emergency. Windows may be cut where sinuses are to be dressed or in order to remove pressure from given points. Lorenz always leaves next to the skin a strip of soft gauze protruding at each end of the completed bandage which the patient can use as a scratcher, to remove crumbs, etc. Pain, offensive smell, or a spot of discharge on the plaster indicates a pressure sore and calls for immediate removal. Generally, plaster bandages may be worn many months. At the Children's Hospital, in recent years, jackets for caries of the spine have been worn undisturbed for a year or more; this was done because during the process of changing the jacket the spine is necessarily disturbed and the deformity may be increased in the handling.

## PLASTER JACKETS FOR POTT'S DISEASE.

Plaster jackets are employed in the treatment of Pott's disease, lateral curvature, round shoulders, and after operations for wry-neck.

**Plaster jackets for caries of the spine** have been applied in many

ways and the one described here, known as the hammock frame method, has been long in use at the Children's Hospital. The jacket is applied with the child lying on his face on a strip of cloth stretched on a frame as the recumbent position relaxes the muscles of the trunk and enables the operator to see exactly how much lordosis is present. The hammock frame, a quadrilateral made of one inch galvanized iron pipe joined by elbows is 6 feet long by 2 feet wide, so supported that the upper end is about 4 feet high, and the lower $3\frac{1}{2}$ feet. Two S hooks at the high end hold an iron rod which is passed through the hem of the hammock while at the lower end of the frame a 15-inch screw with a handle is connected by an iron spreader with a similar bar in the other end of the hammock.

The hammock itself is made of cotton sheeting twice as wide as

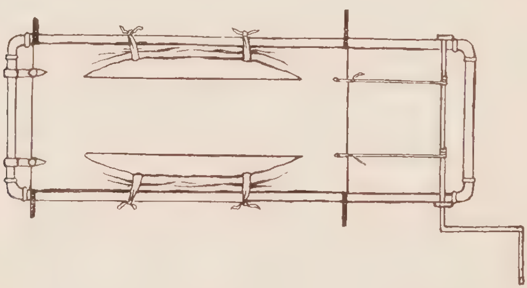

FIG. 158.—Original hammock and frame for jackets; the one described is better in many ways.

the distance between the iliac spines and a little longer than the child is tall; it is doubled lengthwise and a wide hem made in each end. The hammock is attached to the frame, tightened, and the child is placed upon it face downward, with his upstretched hands grasping the top of frame. Around the side bars of the frame, and passing under the hammock, is a tight webbing strap to give support under the sternal notch and a similar tight strap crosses the frame just above the knees. If the hip is flexed by psoas contraction the child may be made to straddle the hammock, the knees are partly bent. The child should wear an undershirt or stockinette covering

and the padding should be adjusted to protect the sacrum, the crests of the ilia, the sternum, clavicles, and axillæ. Felt an eighth of an inch thick answers for this purpose. At the point of deformity pads of felt, an inch or more thick, are placed extending over the transverse processes opposite the point of deformity and for an inch or two above and below as well. No padding is allowed over the spinous processes. The bandages are then applied up to and including the point of deformity; each layer is rubbed in and the jacket allowed to set, during which time the child lies quiet. Then by loosening the screw the hammock is allowed to sag under the child's weight. The lumbar spine, being held by the plaster jacket, is thereby prevented from further bending, so that the sagging produces a backward bending at the point of deformity against counterpressure from the straps under the sternal notch and beneath the thighs; the deformity can often be corrected considerably by the pressure of the surgeon's hand over the upper portion of the jacket; more plaster bandages are then applied to complete the jacket, and it is again allowed to harden. It is easy to apply a jacket like a figure of eight, leaving the upper portion of the abdomen exposed if desired. If it is necessary to carry the jacket over the shoulders, to incorporate in it a plaster collar or helmet, the upper portion of the jacket is made high in the back, otherwise it should cover the lower angle of the scapulæ above, and end below at the center of the sacrum; in front it should cover the sternal notch and more than half of the clavicles, and it should be cut out under the arm pits freely.

FIG. 159.—Plaster jacket applied on a hammock frame, notice the transverse ridge where the two sections of jacket join.

To remove the child from the frame, he is supported while the hammock cloth is cut above and below. It is better to have him stay after completing the jacket on the frame about ten minutes or until the plaster is well hardened, but if it be necessary to remove him before the plaster is entirely set, he should be laid on a table with his back arched up with pillows between the head and hips. If one wants to add shoulder pieces, a collar or a helmet, the hammock is no longer a convenient place. The child should lie on a table with the head and shoulders projecting beyond the edge, supported by an assistant; after padding the parts with cotton, plaster bandages are applied, carefully rubbed and incorporated into the already well-hardened jacket.

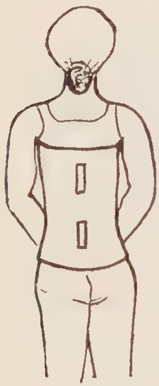

FIG. 160.—Plaster jacket with windows cut.

## PLASTER BED.

It is often desirable in Pott's disease to make use of the plaster bed, a plaster shell for recumbency to keep the back well arched, either for the prevention of deformity or for the paralysis.

The hammock made slack is an excellent place to make it on; with the screw the amount of hyperextension which can be comfortably borne is easily regulated. The patient lies face down and the plaster bandages are applied after protecting the skin and hair with cloth or thin pads; the bandage turns pass upward and downward from the top of the head to half way between the gluteal fold and the bend of the knee. Five layers of these long forward and back turns are applied from the top of the head to the bottom of the plaster, 3 radiating from the point of deformity as a center, and two extra layers are applied to the sides of the bed in straight longitudinal turns, then cross turns cover in the whole shell; if necessary for strength, pieces of wire gauze may be incorporated or thick strips of cotton batting soaked in plaster cream may be added to the outside to strengthen it. When well hardened it is lifted off, and the patient's back is washed, dried, and he is dressed, and returned to bed. The pro-

visional padding is then removed and the walls of the plaster bed carefully smoothed, the shell trimmed, cut away from the arm pits and the whole thoroughly dried and shellacked. Fresh padding is then suitably fitted to the bed and stork linen to cover the lining over the buttocks and the patient is carefully rolled onto his side and then into his plaster bed to which he is attached by circular turns of bandage. By cutting away the part which covers the top of the head, traction may be added, either in bed by weight and pulley or by the jury mast incorporated in the plaster bed if he is to move about in a go-cart. See page 222, Fig. 115.

### OTHER METHODS OF APPLYING PLASTER JACKETS.

Different surgeons and different hospitals have different methods of applying plaster jackets and what each uses most he uses best. The recumbent position has always commended itself to the writer because it conduces to the comfort and quietness of the child and allows a fair amount of correction of deformity by the weight of the child's body. A frame similar to the hammock frame, with the patient lying on his back, is used by Goldthwait for applying the plaster jackets.

*Goldthwait Method.*—In the center of the frame, a hanging cross-bar carries a short upright with a forked end adapted to receive the upper ends of two soft flat iron bars which sustain the spine like the two uprights of a brace; they are bent for each case and give the proper amount of hyperextension to the back. The lower end of these bars is supported on a cross-bar running from side to side at the level of the hips, where they are clamped by a simple turn button into slots. The head and feet are supported on adjustable pillow and crosss straps. Thick felt padding is put on the soft iron flat bars and the child prepared for his jacket, wearing an undershirt, is laid upon them, so that the top of the bars or uprights comes a little above the kyphos and the head and feet are supported on the straps (the head is supported on a small pillow on two straps across the frame); by loosening the straps excellent correction is obtained. The legs and feet rest on a board.

The jacket is applied in the usual manner with the iron uprights

inside of it. The bandage is reinforced in front by half turns up and down; after setting, the turn button is unclasped, freeing the bottoms of the upright iron bars, and allowing the patient to be lifted from the frame and laid on his side on the table or bed, when the uprights are easily slipped out. The jacket is trimmed in the usual way.

*In Brackett's frame* the patient is on the back, only instead of lying on long iron bars he is supported at the kyphos on two short metal plates well padded with felt which are raised or lowered on a Y-shaped support to give the proper amount of correction to the deformity; the plates are left inside the jacket.

FIG. 161.—Brackett's frame for applying a plaster jacket.

*Lovett Frame for Jackets.*—In Lovett's frame for applying plaster jackets, the patient lies on his face on two broad webbing straps with a cross strap at the trochanters and one at the level of the forehead; the upper half of the frame is made double and hinged and the straps secured to it; with legs hanging down to ensure a straight lumbar spine, the first half of the jacket is put on up to the point of deformity and allowed to harden; then a webbing strap is tied across over the child's back at the point of deformity thickly padded, and the hinged front half of the frame is raised by an assistant, thereby raising the upper part of the trunk against pressure from the strap over the kyphos. This force has to be graded to

suit the patient's feelings. The upper half of the jacket is then applied, and thoroughly incorporated with the lower part.

*The Kyphotome.*—Taylor, of Baltimore, uses an appliance called a kyphotome attached to an ordinary office stool, bearing on the top a bicycle saddle; back of the patient there is fixed to the stool an iron upright six feet high bearing a cross bar from which handles and a Sayre head sling are suspended; this stout upright rod is jointed and bears a circle with holes in it so that the extension may be applied directly above the patient's head, or it may be tipped backward so that he is pulled back considerably; just below the joint is an adjustable rod or lever for making pressure upon the kyphos during the application of the jacket; the feet and thighs are secured to the side of the stool by straps.

The patient, in his undershirt, is placed on the saddle, his legs and hips are strapped in, the part of the spine below the deformity is made perpendicular to the floor by means of the pressure rod which is placed a little above the apex of the kyphos; then the head sling is put on and as much traction made as the patient can bear, the hands being extended upward and backward on the handle rods; the upright above the pressure rod is then tipped back to any angle desired and fastened, strongly extending the spine. The reason for placing the pressure rod and its pads above the kyphos is that the child rises under extension slightly; the jacket is then applied.

This method is applicable to lumbar, low dorsal, and mid-dorsal cases which require plaster collar. Anæsthesia is not needed.

Taylor also uses a recumbent kyphotome attached to a table, which he can use both for lateral curvature and for Pott's disease.

The original method of Sayre of applying the jacket in partial suspension is an excellent one and is much used.

## PLASTER-OF-PARIS JACKETS FOR LATERAL CURVATURE.

The jackets are applied for lateral curvature either for support, or for the forcible correction of deformity.

The plaster jacket for support may be applied on the hammock

frame or by other methods. Some correction of the lateral deviation is obtained by a padded webbing strap passed around the chest opposite the point of greatest deformity and around the side bar on the opposite side of the frame, while counterpressure is made by two similar straps, one around the pelvis and the other at the axilla; by tightening these straps and arranging the padding some straightening may be had even in stiff structural cases. Rotation of the ribs may be corrected by pressure with the hands, by hanging weights upon these straps, or by screw pressure from adjustable bars on the frame. The jacket is then applied in the usual manner all in one piece; after hardening, the webbing straps are cut close to the jacket and covered with an extra layer of plaster bandage.

More forcible correction may be obtained with Taylor's kyphotome or modification of the hammock frame of Adams and Lovett. This consists in three circles of iron, almost as wide as the frame, which are adjustable toward the head and foot and also can be turned; each bears an adjustable plunging rod to press on the chest or back through a metal disc thickly padded with felt. The lateral deviations are corrected by straps, the rotations of the ribs by the pressure of the discs; the jacket is put on in the usual way, leaving the discs inside; it is easy to apply more corrective pressure than a patient can tolerate, and is therefore better to apply two or three jackets a month apart than to try to accomplish too much at once.

## REMOVABLE JACKETS.

**Plaster jackets** may be made removable by cutting an inch out of the front of the jacket and sewing on each side of the cut a strip of leather with eyelets or hooks for lacings. The top and bottom of the jacket may be bound with sheepskin.

**Leather Jackets.**—The strength and efficiency of a plaster jacket is materially impaired by converting it into a removable appliance, and jackets of other materials may be substituted, such as stiffened felt, leather, celluloid, aluminum, and paper-and-glue. These are made on a plaster cast of the trunk made by pouring plaster cream into an old jacket. Leather is simply stretched while wet over the cast and secured by tacking until it is thoroughly dried.

It is then removed, trimmed, and leather strips with eyelets or hooks for lacings sewed at the anterior margins, and it is then thoroughly impregnated with boiling bay's wax to stiffen it. The jacket is perforated every two inches with half-inch holes to lessen perspiration. The advantage of the bay's wax jacket lies in our ability to remodel it over any points where it hurts. By simply heating the place where the change is desired, the wax is melted, and the leather softens so that it can be moulded and held in the desired form with a stick until, in cooling, it resumes its former hardness. The plaster casts for jackets may be altered in shape by carving or by building on more plaster paste, so that the jacket will fit a corrected position of the trunk. Jackets are valuable aids in the treatment both of scoliosis and caries.

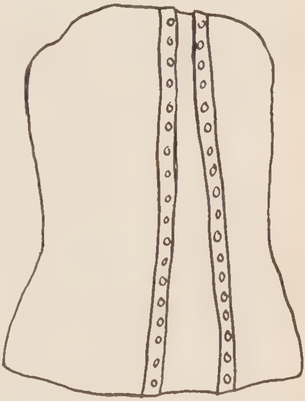

FIG. 162. —Leather jacket.

**Celluloid jackets** are prepared by covering the cast with a merino undershirt or stockinette, and painting on two or three layers of a saturated solution of celluloid in acetone. More stockinette or a layer of bandage is applied as soon as dry, then another coat of celluloid and so on until the desired thickness is reached. These celluloid jackets dry very slowly and if removed before drying is complete, they shrink and curl out of shape. They should be perforated, for celluloid provokes perspiration. Another method by which celluloid jackets are made is the following: a large sheet of the celluloid, softened in boiling water, is stretched on the cast with tongs. The operator, with thick, woolen gloves, quickly rubs it to insure close adaptation, and the jacket is ready for trimming as soon as it is cool. The disadvantage of celluloid jackets lies in the fact that they are hot: their chief advantage is that they are washable and cleanly.

Corsets made of cloth re-inforced with steels and other materials have been used extensively but the support is less efficient even than removable plaster jackets.

## ROUND SHOULDER JACKETS.

Plaster-of-Paris jackets are sometimes used for rigid round shoulders, and the Lovett frame and the hammock frame are useful. The jacket includes the shoulders. Considerable force may be employed but pressing the shoulders forcibly back in such a jacket has resulted in temporary paralysis of the arm like a crutch paralysis. In covering in the shoulders considerable space is left behind over the scapular spines so that every few days, as the shortened tissues yield, the shoulders may be pressed farther back and held there by tucking more felt in front of the shoulder. Three to six weeks in one of these jackets makes a tremendous difference in the attitude of a patient.

## CLUB-FOOT.

Plaster-of-Paris bandages are used for club-foot in different ways, first, for the gradual corrections of infants, second, for the gradual correction in successive stages employed by Wolff, and third, for maintaining the correction of club-foot after operation.

**Infant's Plasters.**—Correction of club-feet by successive plaster bandages is easy in infancy and early childhood, provided, with patience and care, the patient can be humored and made docile. The only difficulty is holding it still in an overcorrected position while the plaster sets. To guard against pressure spots (babies will kick and disturb the setting of the bandage) it is necessary to envelop the foot and limb as far as the middle of the thigh very thickly with cotton batting.

Narrow plaster bandages, two or two and a half inches wide, should be used; one may suffice for a small baby's foot. The writer prefers to apply a bandage as quickly as possible from the tips of toes to half way up the thigh, rubbing and holding it before the set actually begins. This requires some speed with quick-setting plaster bandages and in older children where several bandages are required cannot be done. Success depends on holding the bandage afterward; it should be done as follows:

With the baby lying on the mother's lap the operator grasps the

knee, raises the thigh vertical and bends the knee to a right angle in one hand, and with the other (left for a right foot), grasps the sole of the foot so that the thumb is on the inner border over the bunion joint and the pisiform bone comes opposite the cuboid, the palm of the hand presses the sole upward, the thumb turns the front of the foot outward, and the pisiform bone presses the cuboid upward. The position aimed for is an exaggerated calcaneo-valgus, with as much exaggeration as possible,—one cannot have too much.

It is well to wind some cotton between the toes, removing it afterwards to prevent lateral compression, and to leave a soft cuff at the top of the bandage. A coat of shellac should protect a baby's bandage against wetting with urine.

It is difficult to stop the infant's kicking, but if he be allowed to wave his arms and the other leg freely in the air, there is much less danger of his cracking the plaster than there is if he gets a firm purchase for them.

Until overcorrection has been secured, the bandage should be renewed every week or two afterwards once a month. Little tin shoes and splints of various kinds may be incorporated in the plaster for the correction of infantile club-foot.

**Wolff's Correction of Club-foot.**—Wolff corrects club-feet gradually or as he calls it by stages. He applies the first bandage with only a slight amount of correction; three days later he cuts the bandage in two around the ankle and removes from the outer and anterior border a segment like a section of an orange; he then corrects the foot so as to bring the cut edges of plaster together and applies a new plaster bandage to hold them there; three days later the same thing is repeated, and in the course of a few weeks complete overcorrection is obtained. He then covers the outside of the bandage with glue and shavings, attaches a wooden sole to it and allows the patient to wear it eight months, by which time he expects the bones to have altered their shape so that danger of relapse is over.

**The Plaster Bandage to Maintain Correction of Club-foot Obtained after Operation.**—The plaster bandage should be applied from below the toes to well above the bent knee with the patient still under ether; the knee should be flexed as before, because if the ban-

dage stops at the knee or if the knee is kept straight, varus correction will be lost, for the plaster bandage turns around the leg as a rubber boot would. In holding the foot in plaster, the pronation, toeing out, and dorsal-flexion should be extreme and pressure should be made to prevent a descent of the cuboid. The tips of the toes should be exposed on the upper surface after the plaster has hardened so as to judge of the circulation.

## THE PLASTER SPICA BANDAGE.

This bandage is very useful in giving rest to the patient in the acute stage of hip disease when he cannot get traction on a frame. For real rest the plaster bandage should extend from the tips of the toes to the axillæ.

The accompanying illustration shows a child on a pelvic rest with spica applied the rest is a vertical iron bar adjusted on the end of a table, bearing a flat plate of iron of No. 18 gauge, about three inches long by two inches wide, for children; a piece of felt on this gives enough softness to the sacrum and allows free handling ling of the patient while putting on the bandage. In private work, a support of some sort must be extemporized for the sacrum; usually a small box can be found and placed near the edge of a table and the patient's leg is held by an assistant; the leg and trunk are bandaged with sheet cotton wadding and the plaster bandages are applied at first from the knee to the umbilicus or the axillæ.

To strengthen spicas which almost always break at the groin, pieces of tin, strips of flat iron, or wood, are often incorporated. The writer has found the following method convenient:

A wet plaster bandage is unwound, pulled, and folded together into a convenient length—about 30 inches; the whole is rubbed between the hands into a solid rope like a stick of molasses candy; it is then applied to the outside of the half finished spica, from just above the knee along the outer and lower side of the thigh to the crest of the ilium, then forward, gradually curving downward through the groin and down the anterior surface of the thigh almost to the knee;

after which more plaster bandages are applied in circular turns about it and the whole rubbed together; one or two of these strengthening beams add greatly to the durability.

## THE PLASTER SPICA AFTER REDUCING A CONGENITAL DISLOCATION OF HIP.

The pelvic rest of the spica support should be provided with a thick, vertical iron rod projecting about six inches above the plate; to serve both for counterextension at the perineum and as a post to attach turns of bandage to. The skin is protected with a layer of stockinette and with felt over the anterior spines and knee. The child, still under anæsthesia, is put on the support and the operator makes sure that the hip has not redislocated, that the attitude is

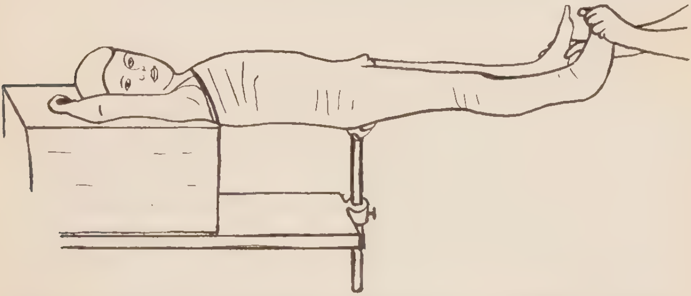

FIG. 163. Support for applying plaster spicas. (*Children's Hospital.*)

correct. One assistant holds the leg in position and steadies the pelvis, another supports the other leg and with the free hand rubs in the turns of bandage as they go on, the nurse wrings and passes the bandages as needed, and the operator stands in front to bandage. Three or four turns are first tightly applied around the pelvis immediately above the trochanter from the well to the affected side, then the bandage is brought over the anterior spine, the trochanter, and across the gluteal fold to the post; taking a turn around the post the bandage returns over itself to the anterior spine, and to the post, again a turn and the same is repeated; by these turns firm inward and

forward pressure is made on the trochanter; then some long turns are made from the crest on the well side over the affected knee and returning behind, which are held in place by regular spica turns, a few of which are made into a short spica on the other leg for still greater fixation. A plaster re-inforcement may be used on the front or back; if the position of Lorenz is used the knee is included and immediately after setting enough is cut from the popliteal space to permit knee-flexion; in the Mueller position, the hanging leg is enclosed in the plaster. The plaster may be bivalved, leaving a small piece uncut at the top and bottom of each cut and bandaging with a wet guaze bandage. The finished plaster shown in the illustration is applied in Mueller's position. Figure 36, page 53.

The spica which Lorenz employs for hip disease goes from the knee to the waist. It is designed simply to restrict hip motions slightly. He encourages weight-bearing during all but the acute stages of hip disease.

## PLASTER-OF-PARIS CASTS.

Casts are made both for a record and also to model splints on. The simple technique for taking casts of the hands, feet, legs, and backs, should be acquired, since the casts furnish the best possible record of deformities. Casts are needed for making plates for flat-foot, spinal braces for hump back, for making leather and celluloid jackets, etc., and for fitting artificial limbs.

**A Cast of the Back.**—Casts are made with slow setting plaster. In order to obtain a shell mold of the back, the patient lies on the hammock frame, a table, or bed, suitably supported with cushions, the back is powdered with talc, and to and fro turns of plaster bandage applied until a shell has been made covering the desired portion about eight layers thick; this will harden in ten minutes, and is readily removed on account of the talc; plaster cream is prepared by adding, little by little, plaster to tepid water, stirring it *gently* to prevent bubbles; the shell, previously powdered with talc, is made horizontal and filled with the cream, and after hardening several hours, the shell and cast are easily parted. For a brace the outline may be marked on the back with an indigo pencil

and enough indigo will come off on the bandage to transfer its mark to the cast for the workman to make his brace by.

**A Cast of the Trunk.**—A plaster cast for a leather or a celluloid jacket is made by applying a snug fitting plaster jacket a little longer than required both at top and bottom; after setting, it is cut and removed with care; the cut edges are brought in contact and bandaged; a stout piece of brown paper is then bandaged across one end, folded up over the sides, and held by some bandage turns; this mold is then stood with the paper side down in a tin mixing pan and is ready to have plaster paste poured into it.

For convenience in making leather or celluloid jackets on these casts, a large wooden spindle, 2 × 2 inches, is usually left standing in the middle of the soft plaster which, after hardening, may be driven through the paper so that the cast can be clamped in a vise by the spindle, to hold it for carving or for the application of leather, painting with celluloid, etc.

**Casts for Flat-foot.**—Various devices have been employed to take casts for flat-foot. The simplest method is to let the patient sit in a chair of such a height that the foot will hang in a pan of plaster cream until the plaster hardens. The impression of the sole of the foot should include the sides as high as the tubercle of the scaphoid, and as the tip of the external malleolus; powdering the foot with talcum prevents its sticking; coating the mold with the same and filling it immediately with plaster cream usually gives a good cast of the surface of the sole. In an hour or two it is hard enough to remove by chipping away the mold.

The surgeon should feel the sole of his patient's foot so as to know how much soft tissue lies between him and the bones; remembering this, he later carves the cast to the shape of the plate which he desires to apply, cutting away from both the sides and bottom to allow for the compressibility of the soft parts and to make the plate narrow enough for the boot.

The cast may also be taken by having the patient cross the knee and place the outer side of the foot on a stool on which is a sheet of cotton with the plaster paste; after the outer border of the foot has taken its permanent position, the cotton with the plaster on it is

lifted up over the sole and inner border of the foot, until it hardens. The advantage of this method is that the foot is both relaxed and thrown into a position of cavus so that it is not necessary to carve away much from the bottom of the cast, only to trim the sides so that the plate will not be too wide for the boot.

# CHAPTER XXI.

## LEATHER SPLINTS AND LEATHER JACKETS.

Molded leather splints for the legs and arms are made on casts from bandages just as leather jackets are. They should be made of oak tanned English leather which is not "filled or stuffed." A paper pattern should be cut of the desired shape, the leather, cut by the pattern, is soaked in water until very soft, stretched over the cast and made to conform to every curve and depression by tacking one edge with a hammer, pressing the leather down to fit the hollows and fastening with tacks on the opposite edge after it is properly molded; or it may be adapted to the cast by tightly winding a small rope around it in close turns; or it may be tightly bandaged with webbing. Sometimes it is necessary to put something beneath the webbing in order to force the leather into the hollows of the cast; it is then allowed to dry, either in the air which takes several days and depends on the condition of the atmosphere, or it may be baked at a temperature, not exceeding 120° F., which hardens and stiffens the leather; when thoroughly dried, hot bayberry wax is painted on until it will absorb no more. This leaves a dull non-absorbent surface which feels slightly greasy to the touch. Strips of leather with lacing hooks, or eyelets should be sewed on the edge. Jackets or splints may be shellacked three coats, which adds to its durability, by making it resist softening from the heat and perspiration of the body. The top and bottom of a jacket or splint may be protected by stitching a strip of soft sheep-skin on the edges but this is usually unnecessary; and any hard place on the border

FIG. 164. Short leather spica splint.

which sticks in, can be softened by slashing into the leather little nicks close together and rubbing it until it yields.

Unless great pressure is brought on them, these jackets and splints need no steels to re-enforce them.

For the method of preparing casts for leather jackets, see p. 363.

## THE MODIFIED TAYLOR BRACE FOR CARIES OF THE SPINE.

The brace consists of two uprights, a bottom piece or base, two shoulder pieces, and one or two cross bars.

*The uprights*, vertical steels at either side of the spines, are curved to fit tracings of the spine made over the row of transverse processes with the child lying face down. The top of the uprights should be opposite the seventh cervical spine, and the lower ends an inch or more below the posterior superior spine of the ilium, provided the child is large enough so that both uprights may pass between the posterior superior spines without striking them and leaving $\frac{3}{4}$ of an inch between. For smaller children they should end at the horizontal part of the base.

FIG. 165.—The Taylor chest-piece or chest expander.

For a child they should be made of malleable steel, $\frac{1}{8}$ of an inch in thickness or a little less (No. 10–12 gauge) and $\frac{1}{2}$ inch wide, and be fitted exactly to tracings of the spine, it is well to fit them also on the back before they are riveted to the brace; opposite the deformity they should each have a thin steel pad plate, $\frac{1}{4}$ of an inch wider than the upright, shaped to fit the curve and if necessary to fit a curve across the back from side to side as well; each is attached by a single rivet at the top. Pad plates should be of spring steel, No. 22 gauge, they may be wedged forward from the upright if any increased pressure is desired, and should be perforated close to the border

with small holes to which a leather or a felt padding can be sewed. The bottom pieces may vary in shape; a U-piece is very often employed here, cut from a sheet of malleable steel, No. 12 gauge, with inverted limbs extending down on each side to a point below and two fingers' breadth within the inner side of the trochanters; on the tips are circular pad plates the size of a fifty cent piece, which are leathered; they should be low enough so that the patient can sit comfortably without striking upon the chair, that is about one inch above the level of the tuber ischii; the width between the tips of the U-piece should be the distance between the centers of two lines connecting on each side the trochanter and tuber ischii.

The shoulder pieces are separate pieces, of malleable steel, the same width as the uprights, (No. 14–15 gauge or $\frac{1}{16}$ of an inch thick) which are riveted to the top of each upright and are bent outward on the flat at an angle of 45° and are bent over so as to conform to the root of the neck; in measuring, an inch or more is allowed below the top of the upright for riveting them on; anteriorly, they end at the forward edge of the trapezius. The cross bars, usually two, are a little shorter than the breadth of the trunk and usually one comes just below the posterior border the axilla, the other lower down; they should have the same width as the uprights, and be $\frac{1}{16}$ of an inch thick; all the parts should be fastened to the posterior surface of the uprights by stout steel rivets. For attaching the brace, straps and buckles are used which are fastened at appropriate places by copper rivets; there should be one pair of buckles at the tips of the U, one at the corners, one at each end of the cross bars, and a webbing strap should be riveted to the tip of each shoulder piece. These buckles (tailor's buckles, 1 inch wide) receive the apron straps which are made of webbing $\frac{3}{4}$ inch wide. The apron covers the anterior surface of the body and is made of stout cotton drilling or canvas; in width it extends from one posterior axillary line to the other, ending above at the axilla, and below at the symphysis, the corners are cut away to allow for the action of the pectorals above and below for flexing the thighs in sitting, but the apron must cover the anterior superior spines and one inch below them. To obtain a smooth fit, gores may be taken; wrinkling may also be

prevented by stiffening the apron at the waist with bones; the apron is made double and finished with a half-inch hem; webbing straps of suitable length to buckle into the brace are sewed on here. Rusting is prevented by nickle-plating the brace or bluing or japanning it. The skin of the back may be protected by felt or thin leather on the uprights, but it is better to have this protective material

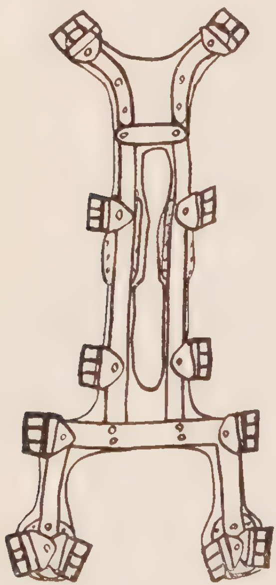

FIG. 166.—Modified Taylor back-brace, old pattern without cross-bars and entire front leathered.

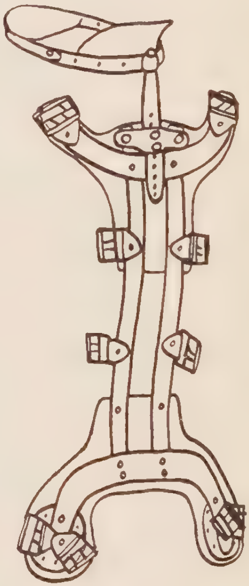

FIG. 167.—Modified Taylor back-brace with oval ring head support, old style brace.

only over parts where it presses most, the pad plates and waist band; when needed perineal straps padded with canton flannel or soft leather, they are fastened in front to buckles sewed an inch above the lower edge of the apron and behind are buckled to the tips of the U-piece.

Any child with *Pott's disease and forward shoulders* needs in addi-

tion a Taylor chest-piece; this consists of two triangular hard rubber or stiff leather pads made to fit under the clavicles and coracoid processes as shown in the illustration; they are joined together by a malleable iron rod made in two pieces so that it may extend or shorten; the pads are strapped to the shoulder pieces and to the first cross bar of the brace.

## HEAD SUPPORTS.

**The Taylor head support or oval ring** is an attachment to this this back brace for caries higher than the seventh dorsal vertebra; it consists of an oval ring, a spindle and a socket.

*The oval ring* extending from occiput to the tip of the chin, is slightly wider than the angles of the jaw, and is hinged opposite the right angle of the jaw to swing in a horizontal plane, and on the left is fastened by a pin and ring clasp. It is made of spring steel, $\frac{1}{8}$ by $\frac{1}{4}$ inch; on the anterior part beneath the chin, a small tin plate is soldered, about $1\frac{1}{2}$ inch wide and $\frac{3}{4}$ of an inch long and to it is riveted a molded plate of hard rubber or celluloid to support the chin; at the back of the ring is riveted a piece of forged steel with a vertical hole to receive the top of the spindle which both supports it and permits of turning the head; on the inside here is attached a piece of stout leather which gives a soft agreeable rest for the occiput.

*The steel spindle* which fits the hole in the ring is attached to the brace by a socket riveted to the two uprights of the brace; it (the spindle) is bent to the curve of the neck so that the oval ring may support the occiput and chin at the proper angle. It is raised and lowered in its socket by two set screws. The spindle reaches from the occipital protuberance to $\frac{1}{2}$ inch below the socket. It is forged out of soft steel, its lower part is $\frac{3}{8}$ of an inch wide, and $\frac{1}{4}$ inch thick; it is flat on the anterior and round on the posterior surface; in its upper third it becomes circular, ending in a vertical circular pin which accurately fits a $\frac{1}{4}$ inch hole in the socket on the back of the ring, and a small shoulder at the base of the pin prevents undue descent of the head support.

The socket, a piece of machine steel, is riveted at each end to one

of the uprights of the brace; it is sufficiently thick in the middle to have a hole through which the wide part of the spindle passes. Machine steel, $\frac{1}{2}$ inch wide and $\frac{3}{8}$ of an inch thick, is used. The dimensions for the hole are the same as those of the lower part of the spindle. Two set screws turning in threaded holes in the posterior half of the socket hold the spindle from slipping, fitting into depressions in its surface.

## WIRE CHIN REST.

The wire chin rest is intended to be used with a plaster jacket or a steel brace. It is less efficient than the oval ring as a head support. It is made of a piece of wire and an occipital half band of steel. The wire is bent into a U-shape to rest upon the chest and shoulders and is sufficiently sprung forward to allow clear space over the clavicles. The width between the vertical branches of the U is equal to the horizontal distance between the centers of the clavicles; in length they extend from the level of the xiphoid cartilage to the border of the trapezius muscle. Here with a right angled bend the wire rises to a point just behind and slightly outside the angle of the jaw and there takes a right angled bend forward and curves under the jaw to the chin. This apparatus should first be fashioned in flexible wire on the child, then duplicated in stout wire, $\frac{3}{16}$ of an inch (No. 5 or 6 gauge) in diameter, the ends of the wire should meet in the horizontal part of the U-piece on the chest, not under the chin. Around the right vertical part behind the angle of the jaw is wound an end of the posterior half-band of flat malleable steel, $\frac{1}{4} \times \frac{1}{16}$ inch, made to swing open like a hinge and shut close to the back of the neck; up and down movement is prevented by soldering a small shoulder on the wire below it. On the

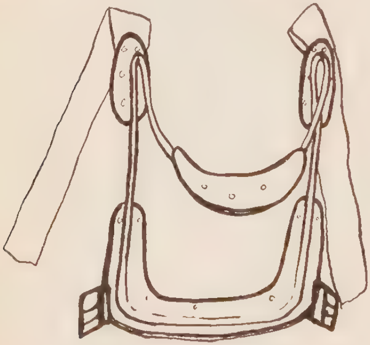

Fig. 168.—Wire chin rest.

left, a small hook-shaped bend at the tip enables it to clasp itself to corresponding place on the left upright; one or two short wire rods riveted near the middle of this posterior band support pad plates for the occiput to rest on. Beneath the angles where the uprights rise at the base of the neck and extending for 1½ inches both forward and back of these points are soldered oblong pressure pads of thin steel or brass, ¾ of an inch wide and 3 inches long; under the chin a small piece of tin is soldered to receive a hard rubber chin plate molded on a plaster cast of the chin like the one described in the oval ring head support. Under the horizontal part of the U and ascending 3 inches upon either branch is soldered a strip of tin 2 inches wide lined with leather to give a broad flat bearing on the chest.

A short webbing strap riveted to the under side of each shoulder pad plate fastens the apparatus to buckles on the shoulder pieces of the brace; from the right lower corner of the U-piece a strap passes around the body to buckle on the opposite side and secure the support from slipping sideways. Instead of the occipital pads on the posterior half band, the band may be thickly wound with felt or may have riveted to it a piece of jacket leather to support the occiput.

When the wire chin rest is used with a plaster jacket two flat vertical uprights of malleable steel should be incorporated between the layers of the jacket, bearing each a buckle for the straps from the head support.

## THE GOLDTHWAIT HEAD SUPPORT.

**The Goldthwait head support** consists of the upper part of a wire chin rest soldered on to a flat metal piece, ½ inch wide by $\frac{1}{16}$ of an inch thick, which is to fit like a yoke on the chest and shoulders, extending down the back as low as the lumbar region. This gives a much firmer support to the head and shoulders but is more difficult to make on account of the peculiar curves in the flat metal yoke. To obtain a pattern for this yoke-piece a lead strip ½ inch wide is molded on the child so as to lie exactly where the yoke is to go. This is carefully removed, laid on its side and a profile tracing made from it. The lead strip is then carefully turned so

that a tracing may be made in its frontal plane also, after which it is flattened out and a paper tracing taken of the remaining curve. This tracing is then cut out of paper and placed on the child to see if it fits exactly in place and corrected so that it does so. Either a piece of flat malleable steel, ½ inch wide and $\frac{1}{16}$ of an inch thick, may be forged and bent hot to correspond with the curves of this piece of paper or the piece may be cut from a sheet and bent in the cold to correspond exactly with the curves in the two tracings, the one in profile and the one in the frontal plane. The wire portion is made exactly as for a wire chin rest without the part for the chest; instead at the base of uprights the wire runs forward 2 inches where it is cut off. These short ends, flattened and properly curved, are soldered to the yoke after trying it on and marking where they go. The apparatus is kept in place by a strap and buckle between the tips of the yoke and another from the same point encircling the body. It is applied by opening the posterior half band, pushing the ends of the yoke back on either side of the neck until the apparatus falls into its natural place then the neck band is clasped and the straps fastened. This apparatus with slight modifications is the one used for torticollis.

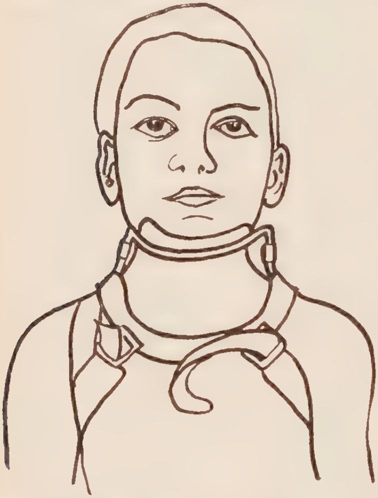

FIG. 169. Goldthwait head support applied.

## THE TORTICOLLIS BRACE.

The object of this brace is to keep the head in the overcorrected position after operation. The Goldthwait head support is used at the Children's Hospital for this purpose. It has to be modified slightly to suit this deformity. The modifications affect the

wire portion only, the yoke remains the same. The wire support under the chin should be made to hold the head looking to one side, instead of straight forward. The hard rubber cup for the chin must be enlarged so as to press on one side of the chin to maintain position, and an upright with a pad plate is riveted to the posterior neck band so as to press upon the parietal boss on the side of divided

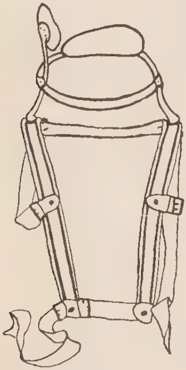

FIG. 170.—Support for torticollis.

FIG. 171.—Same applied.

muscle. This will be readily seen by reference to the accompanying illustration. The object of the brace is to maintain the ends of the divided muscle as far apart as possible.

## THE THOMAS COLLAR.

**The original Thomas collar** was a strip of soft calf skin sewed at the edges into a tube and stuffed with saw dust. The diameter was greatest under the chin and smallest under the ears and it was fastened together with two small straps and buckles at the back of the neck. A greater or smaller amount of saw dust increased or diminished the amount of support. Such a collar can be made by any saddler, but it is somewhat clumsy. A similar support may be made by winding upon a webbing strap or a piece of bandage, alternate layers of oakum and bandage; or a central core of stiff leather

or card board cut to shape may be wound thickly with oakum and bandage. Stiffened leather, woven-wire netting, aluminum, and celluloid collars may be made on a cast of the neck and shoulders just as a leather jacket is. The Thomas collar may be used efficiently with a plaster jacket, if the jacket extends over the shoulders.

### THE QUADRILATERAL BACK BRACE.

**The quadrilteral back brace** was designed by Dane to combine the efficient antero-posterior support of a back brace with the prevention of side bending secured by the plaster-of-Paris jacket. The uprights are here separated so that they rise vertically over the angles of the ribs. Pressure on the transverse processes at the point of deformity is obtained by a detachable transverse band, bearing pad plates.

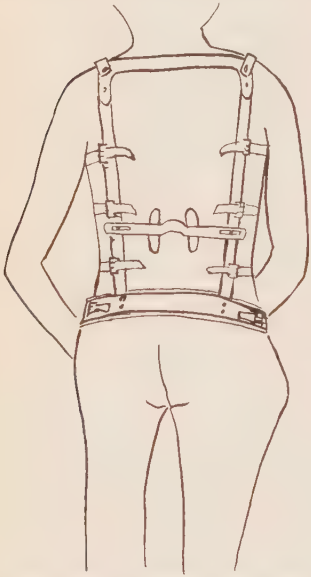

FIG. 172.—Dane's quadrilateral brace. Note abscess from right hip disease.

*The pelvic band* of No. 15 gauge cast sheet steel is bent to fit across the back at a point just above the trochanters. It ends on each side close behind the anterior superior spine and slightly below it.

*The uprights*, of No. 12 gauge flat steel a half inch wide are riveted to the upright, well outside of the posterior superior spines; they rise vertically over the angles of ribs to end a finger's breadth above the spines of the scapulæ where the descending arms of the top bar are riveted to them; the uprights follow the curves of the flank but do not press hard upon the skin over the lower angle of the scapula, but do press on the rest of that bone when the shoulder straps are tightened. The length of the top bar is the distance between the glenoid cavities of the scapulæ with the shoulders fully back; its ends are bent at a right angle downward and are

continued downward one additional inch for riveting on to the uprights.

*The Pad Plate Bar.*—This is a horizontal bar of half-inch flat steel, No. 14 gauge, secured to the uprights by screws at the level of the kyphos. In the middle is a small backward curve to clear the spinous processes and beside that curve are the pad plates of No. 18 gauge sheet steel, $\frac{1}{2}$ inch wide and 3 or 4 inches long, so shaped as to press exactly upon the transverse processes. To facilitate adjusting this bar the screws that hold it to the uprights pass through slots instead of round holes; this bar requires very careful fitting with wrenches.

From each upper corner of the brace two webbing straps pass, one round the shoulders buckling to the side of brace, and one to the front of the apron. On each side two side straps from the apron fasten in buckles on the uprights, and one to a buckle on the end of the pelvic band. The apron is made of jacket leather $\frac{1}{16}$ to $\frac{1}{8}$ of an inch thick; it should extend from the level of the ensiform to the top of the pubis in the median line and from same level to an inch below the anterior superior spines on the sides. Webbing straps are sewed to it opposite the buckles and brace.

*The head support for this brace* consists of two flat uprights which are adjustable vertically by means of sockets and set screws on the top bar and the pad plate bar, a strap or sling for the occiput, and a strap for the forehead. The uprights are flat malleable steel bars, $\frac{1}{2}$ inch wide and $\frac{1}{12}$ of an inch thick, starting $1\frac{1}{2}$ inches below the pad plate bar, they are left perfectly straight until a finger's breadth below the occiput, where they are forged into round rods, curving upward and outward to a point an inch above and $\frac{1}{2}$ inch behind the ears, where they turn forward horizontally close to the head as flat bars, ending at the edge of the hair, where the buckle is riveted on each side for the forehead strap. The occipital strap is riveted to one of the uprights at the angle where it becomes horizontal, it buckles at a corresponding place to the other upright. It is reinforced on the outside with a thin strip of brass $\frac{1}{4}$ of an inch wide to prevent curling. The frontal strap is of calf skin, one inch wide where it crosses the forehead, tapering to fit the buckles.

### THE WRITER'S MODIFICATION OF TAYLOR'S BACK BRACE.

This brace, originally intended for the correction of rigid round shoulders, has been in use for five years at the Children's Hospital, for Pott's disease of the lower dorsal and dorso-lumbar spine. It is designed to avoid displacements from muscular effort, to encourage free chest and lung expansion, and to hold the dorsal spine in a position where nature locks it against all lateral and rotary movements. The uprights are fashioned precisely as for the Taylor back brace and are placed directly over the transverse processes, the space between uprights rarely exceeding an inch in children. Pad plates are used.

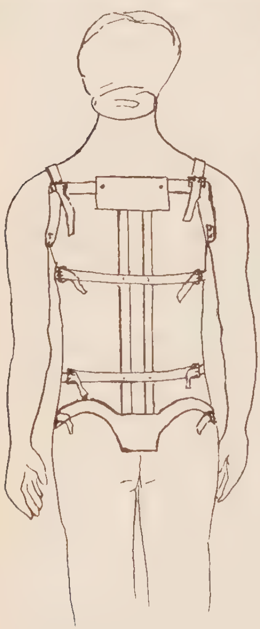

FIG. 173.—Brace for rigid round shoulders.

The bottom piece covers most of the sacrum and rises so as to follow close below the iliac crests to a point behind and below the anterior spine. This shape conforming to the outer surface of the ilium just below the crest covers a space where the muscles are thin, and by their contraction cause very little displacement. The lower cross bar of the brace is made to fit the loins just above the iliac crest, and prevents sagging down of the brace. The upper cross bar is placed below the tips of the scapulæ.

At the top the uprights are riveted to a plate an inch wide and 3 inches across so that it projects at least a half inch outside of the uprights. To this are loosely riveted movable shoulder pieces of 16 gauge steel cut L shaped. The angle of the L comes behind the glenoid cavity when the shoulder is back and the lower end descends 3 or 4 inches and curves forward into the axilla so that the axillary strap from its end which encircles the shoulder and buckles to the angle of the L cannot possibly press upon the axillary vessels and nerves. The

short arm of the L is loosely attached by a rivet in the outer border of the plate so as to allow a little movement.

The apron may be of leather or cloth; it extends from the breast to the symphysis in the median line and on the sides from just below the anterior superior spine to a point in the middle axillary line op-

FIG. 174.—The same applied for dorsal caries.

posite the upper cross bar. Straps attach it to buckles on the pelvic band and cross bars and an additional strap is often needed at the waist.

### THE FLEXIBLE OR SPRING STEEL BRACE.

When employed for round shoulders, the plate, movable L pieces, and axillary straps may be used on top of a light flexible spring steel

brace. This flexible brace is also used at the end of the convalescent stage of Pott's disease and affords a slight protection to the spine. It is made usually of a horizontal pelvic band which encircles the posterior part of the pelvis ending on each side at a point one inch behind the anterior superior spines. This should not be made out of a straight flat piece of metal; a paper pattern should be fitted on the child to get the proper curve, and it is cut from 16 gauge sheet steel $1\frac{1}{8}$ inches wide. The uprights extend from it an inch to $1\frac{1}{2}$ inches apart vertically to the level of the first dorsal spine, where they bend outward at an angle of 45° extending as shoulder pieces for about 2 inches; the space between the uprights should be 1 inch at the top and $1\frac{1}{2}$ inches at the bottom. They are made of No. 16–18 gauge spring steel $\frac{1}{2}$ or $\frac{5}{8}$ of an inch wide; and should be bent to follow the general outline of the back only; the lumbar curve is much exaggerated and the upright is spring tempered. A cross bar $\frac{1}{2}$ inch wide is riveted to the uprights an inch below the posterior axillary folds; it should be 1 inch less on each side than the width of the back and shaped to avoid pressing on the scapulæ. Holes are drilled for buckles at the ends of cross bar and of the base band. Straps connect the tips of the shoulder pieces to buckles at the ends of the cross bars; they should be padded with soft leather. Where the abdomen is protruding, a leather abdominal band, 4 to 5 inches wide, should be sewed to each upright at the waist and made to fasten in front with straps and buckles.

## BRACES FOR LATERAL CURVATURE OF THE SPINE.

The variety of braces which have been used for the treatment of this deformity is very large. At the Children's Hospital, the one at present in vogue was devised by Keen, of Boston. It is a modification of many others.

The brace consists of a horizontal pelvic band similar to that last described. An upright in the middle of the back extends to the vertebra prominens and a lateral upright from the front of the pelvic band to the anterior part of the axilla on each side. Two posterior half bands, one at the waist and one at the top, convert this into a close fitting posterior shell into which the trunk is strapped.

### REMOVABLE JACKET FOR LATERAL CURVATURE.

Removable jackets for lateral curvature are to be modeled, not on the cast of the patient, but on that cast after it is carved and corrected to suit the requirements of the case. This must be done by the surgeon; he can do it better with the patient's bare back before him. Humps from backward rotation of the ribs are smoothed down, or shaved off with a chisel or draw knife, and he builds up the unnatural hollows with fresh plaster paste until a back with the required amount of correction has been fashioned in plaster on which the jacket is to be made.

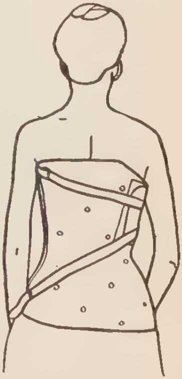

FIG. 175.—Leather jacket for lateral curvature made over corrected cast.

When the jacket so prepared is applied and worn it is often desired to obtain still more anterior pressure or side pressure on the rib hump and to allow more room over the depressions. This may be accomplished by cutting out a piece of the jacket over the rib hump and strapping it into place again so as to exert on the hump strong strap pressure which may be varied by the direction of the straps and buckles; over the depressions which are to fill out windows may cut and left open.

The same principle is used in the brace.

## APPARATUS FOR LATERAL CURVATURE DESIGNED TO ALLOW RESTRICTED MOVEMENTS IN THE BACK.

Wullstein, who probably applied forcible correction with greater force than anyone, except Calot devised a brace with a head support, constructed so that some movement is permitted in the lumbar spine by inserting in the upright spiral springs made of a flat steel rolled like a paper alumette. His brace consists of a base made of a pelvic girdle of leather, reinforced with a metal pelvic band and two metal strips over the iliac crests which constrict the pelvic band slightly, just above the crests. The spiral springs, are attached to the pelvic band, $1\frac{1}{4}$ inches apart, and to the upper ends of these, vertical

flat steel uprights bearing at the level of the shoulder-blades a cross piece to support the arms. Attached to the cross piece and to the metal uprights is a moulded leather pad to press on the rib hump so that pressure can be increased from time to time. The spiral springs permit movement in the lumbar column, and at the level of the atlas a joint with limited motion allows slight rotary movements of the head. The flattened part of the thorax opposite the rib hump is left free but the anterior rib hump receives the pressure of leather straps arranged not to press upon the opposite side of the chest, while the forward pressure on the posterior rib hump is regulated by a modeled leather pad and set screws.

The head piece, made on a cast, covers the entire occiput and half of the squamous bones. The head is secured in it by a broad forehead strap. The chin is left free. As much pressure may be applied to the trunk in this brace as the patient can stand.

## HIP SPLINTS.

**The traction hip splint** used at the Children's Hospital is a modification of that of C. Fayette Taylor, of New York.

It consists of an upright, a foot piece, a waist band, two half bands for the thigh and one for the calf.

*The upright* is a square steel rod connecting the waist band and foot piece, the latter ends three inches below the heel and the upright runs from it to a point in the line of the leg opposite the anterior superior spine; it may often be a straight rod but as often it has to be curved to fit the thigh and knee, which is done by bending it to conform to a paper tracing of the limb; sometimes the lower end is half rounded and is perforated with screw holes to attach to an adjustable foot piece, and sometimes it is itself prolonged into a foot piece by forging two right-angled sharp bends after first flattening the lower six inches to a width of $\frac{5}{8}$ and a thickness of $\frac{1}{4}$ of an inch; the upper end is flattened out by forging into a small oval plate to be riveted to the waist band; this oval is about $1\frac{1}{2}$ by $\frac{3}{4}$ or $\frac{7}{8}$ of an inch, with the long axis not at a right angle to the rod, but making an angle of seventy degrees with the front of the upright. $\frac{5}{16}$, $\frac{3}{8}$,

and $\frac{7}{16}$ are the sizes of rods for little and medium children and adolescents. After forging and bending to shape, the upright is heated and tempered to make it rigid. In the oval plate at the top three rivet holes ($\frac{1}{8}$ inch) are bored and, if an adjustable foot piece is to be attached, seven threaded holes for one-eighth inch machine screws are made a half-inch apart.

*The adjustable foot piece* is forged from the same metal eleven inches long, the upper end is flattened into an oval and the projecting sides turned up to clasp the half round upright; it is perforated with a row of screw holes. In the lower half it is forged $\frac{5}{8}$ inches wide, and $\frac{1}{4}$ of an inch thick; three-fourth inch is then turned over at the end at a sharp right angle and a similar angle is forged $2\frac{1}{2}$ inches farther up to form the foot piece. A $\frac{1}{4}$ inch hole is bored in the turned up end $\frac{1}{2}$ inch above the ground, and one in the upright opposite to it for the windlass spindle. The latter $3\frac{1}{2}$ inches long, $\frac{1}{4}$ of an inch in diameter, is squared at one end and is held in place by a pin through it inside of the projecting part of the foot piece. It projects beyond the outside surface of the upright for $\frac{1}{2}$ of an inch. Outside next to the upright there is attached to it a half-inch ratchet wheel, which is controlled by a spring and stop $1\frac{3}{4}$ inches long, fastened to the upright by pins. The projecting square end of spindle is made to fit a clock key. The center of the spindle is filed half way through on one side and a slot cut out and in from this point to within $\frac{1}{4}$ of an inch of the foot piece to receive the webbing straps of the extension.

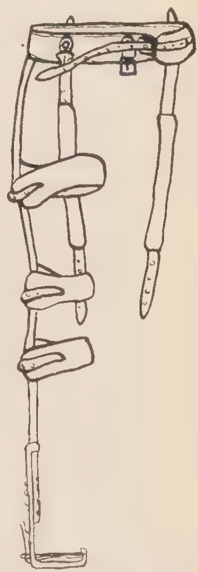

FIG. 176. — Traction hip splint.

*The waist band* is made of flat steel one inch wide, called tire steel, No. 8 gauge. The posterior half is one inch longer than the anterior and is bent in a more gradual curve; the anterior half must be carefully fitted. It extends from the middle of the outside of the thigh above the trochanter to a point just over the opposite anterior supe-

rior spine. It is forged so that the anterior and posterior arms are parallel to each other in vertical planes when the waist band is inclined 20° to horizon. The waist band is fastened to the flat oval top of the upright, with the posterior arm higher, by three stout steel rivets. In large heavy patients this is sometimes insecure; and for them the upright should be left square and a piece of machine steel is prepared to fit round it and extend $1\frac{1}{2}$ inches along the waist band in front of and behind it. A $\frac{3}{16}$ inch rivet holds this forged piece, the upright, and the pelvic band together and similar rivets attach the forged piece and waist band in front and behind, making it very strong. Buckles are fastened to the pelvic band, outside of the leather padding, two in front and two behind, for the perineal straps. At the back they should be half way between the trochanters and the posterior superior spines. In front they should be closer together but leave ample room for the genitals. Another buckle attached to the anterior end of the pelvic band receives the belt strap. The waist band is lined with felt and covered with soft leather stitched at the edges; at the posterior end this leather is prolonged into a belt to go the rest of the way round the waist, or a strap of jacket leather, $1\frac{1}{4}$ inches wide, is riveted there which buckles to the end of the anterior arm.

*Posterior Half Bands to Secure the Leg in the Splint.*—Generally three bands are used in older children, two in small ones—one at the middle thigh and the other at the upper third of the calf; they enclose half the circumference of the leg and the strap holds the rest. These are strips of steel, No. 14 gauge, 1 inch wide; fastened to the inner side of the upright by soft pieces of steel similar to that described for attaching a pelvic band for heavy patients, but smaller, and fastened by screws which may be loosened to adjust up and down on the upright. These bands are padded with felt and covered with thin leather; to the free end is riveted a webbing strap to pass around the leg and buckle to the band behind the upright of splint.

*Perineal bands* are made of webbing wound with canton flannel; or, leather may be used, padded with felt, and covered with chamois or moose-hide. For children who habitually soil them, a webbing

strap may be passed through a rubber tube about $\frac{1}{2}$ inch in diameter which gives padding enough. As these straps are worn under tension one must take care to prevent the skin from chafing and to guard against pressure sores. The stitches in the canton flannel must be away from the skin, the straps are to be loosened two or three times a day and the parts bathed in alcohol and powdered with talc.

The splint is used with a high sole on the well foot, and crutches, and it swings clear of the ground in walking.

## CONVALESCENT HIP SPLINT.

**The convalescent hip splint** is usually made out of the patient's old splint. The lower end may either be arranged to fit in a steel socket fastened to the shoe and projecting upward on the inner side of the foot; or, a simple end like a crutch tip may be forged on to rest on the ground. This splint, designed to allow the patient to walk upon the toes, makes it impossible to touch the heel to the ground or to pound his weight upon it. To convert the lower end of the traction splint into a convalescent one, it is cut 3 inches from the ground and there is welded to the upper part a piece long enough to extend 2 inches below the sole of the boot, where it expands into a bulbous tip $\frac{3}{4}$ of an inch in diameter, over which a crutch rubber may be stretched. The total length of the splint should be the distance from the anterior superior spine to the bottom of the heel of the shoe with the foot at right angles plus $1\frac{1}{2}$ inches. If it be desired to have a splint of adjustable length, after cutting off the lower end of the upright, it is forged flat on inner side, and rounded on the outer, and is perforated with threaded holes $\frac{1}{2}$ inch apart to receive the set screws from the adjustable foot piece. The upper end of the latter is drawn out into two small clips curving slightly inward to embrace between them the rounded part of the upright so that the foot piece can slide up and down, and is perforated with screw holes $\frac{1}{2}$ inch apart. The screw holes are brought opposite each other and the foot piece screwed to the splint by machine screws.

When a convalescent splint with a socket in the shoe is preferred, the old splint should be cut off an inch above the ground, and the

upright flattened out till it is $\frac{5}{8}$ or $\frac{3}{4}$ of an inch wide for a space of $2\frac{1}{2}$ inches; a slot is then filed or cut out from the end running from before backward, $\frac{1}{4}$ of an inch wide, extending $1\frac{1}{8}$ or $1\frac{1}{4}$ inches upward, and a pin $\frac{3}{8}$ of an inch wide is riveted into it for the socket to turn on.

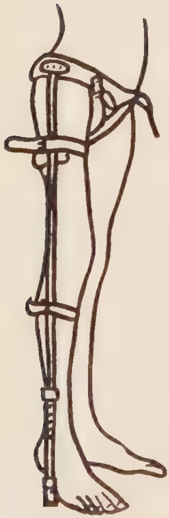

FIG. 177.—Convalescent hip splint with crutch-tip end.

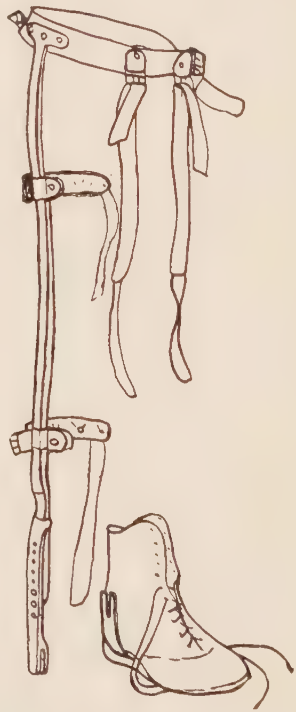

FIG. 178.—Convalescent splint with socket on shoe.

The foot piece made like that for bow-leg irons is similarly attached to the shoe, the upright rises at right angles vertically, $2\frac{1}{2}$ inches. The plate and upright are made of $\frac{3}{16}$ inch sheet steel and the upright should be at least an inch wide with a deep notch as shown in the figure to receive the pin of the upright.

### CONVALESCENT HIP SPLINT JOINTED AT THE KNEE.

This splint carries a single perineal strap buckled to the extremity of short anterior and posterior arms. The upright at the knee curves backward and has a hinge joint opposite the posterior borders of the condyles. The hinge is stopped to allow free bending forward at the knee but prevents back bending beyond a straight line, and the center of motion is far enough behind the line of weight to lock the splint securely without catch.

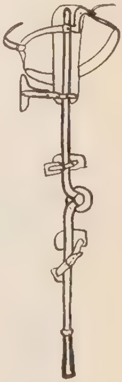

FIG. 179. — Convalescent hip splint jointed at the knee.

### THE DANE HIP SPLINT.

This splint consists of a Thomas knee splint with a windlass and ratchet for extension at the base and with the waist band of a traction hip splint fastened to the top above the ring. The object is extension combined with more fixation than obtains with webbing perineal straps. For counter-extension, he substitutes on one side the ring of the splint as a rigid support to the perineum and in place of the other perineal strap uses a chain covered with felt and chamois skin. The construction may be readily seen from the accompanying illustration. It differs from the ordinary Thomas knee splint in having a stouter upright on the outer side, a windlass and ratchet in the foot piece and a waist band.

To fix the pelvis Dane later altered the waist band by adding to it a second posterior pelvic arm which is carried as low down as possible over the sacrum. These arms are prolonged along the sound side of the pelvis by spring steel strips riveted to a broad leather belt. A firm grasp of the pelvis is thus obtained and movements of the hip-joint are in large measure prevented. It is an excellent splint but demands care in fitting to prevent sores on the perineum from pressure.

### THE THOMAS HIP SPLINT.

This splint is designed to fix the hip-joint and does not contemplate extension. It has an upright, a chest band, a thigh and a calf band.

*The upright* extends vertically in the line of diseased leg and up the back from the junction of the middle and lower third of the leg to the lower angle of the scapula. It has two bends, one opposite the fold of the buttocks, the other just above the hip-joint, so that the leg part and the body part are in parallel planes; the lower part

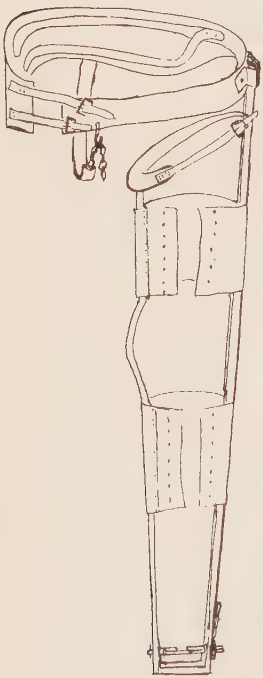

FIG. 180.—Dane's hip splint.

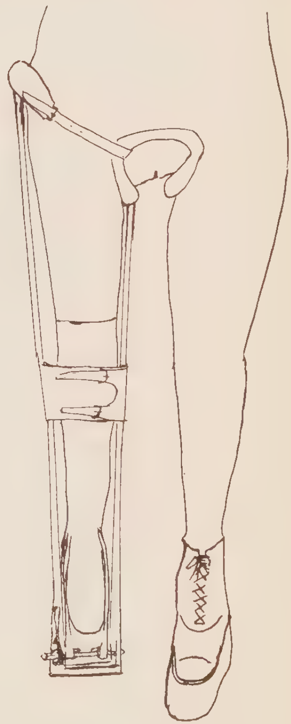

FIG. 181.—Bradford's abduction hip splint applied.

from the fold of the buttock to the lower end of the splint is from a half inch to 2 inches anterior to the upper; the upper portion conforms slightly to the curve of the back but is nearly straight. It is usually necessary to twist the upright slightly on its longitudinal axis so that the body portion conforms to the rounding of the side of the chest,

while the leg portion is in the middle line of the thigh and leg. The bent portion for the buttock extends from the level of the trochanter to that of the tuberosity of the ischium. A child of 10 requires an upright $\frac{3}{4}$ of an inch wide and $\frac{3}{16}$ of an inch thick, of toughest and softest iron.

*The chest piece* is made of strap iron: its thickness (No. 14–18 gauge) and width vary, according to the patient's size. It should be long enough to encircle the chest, leaving a gap of 2 inches between the ends; it is fastened to the upright, not in the middle, but enough to one side to bring the gap over the front of the chest in the median line. If riveting is not sufficiently secure, the upper end of the upright may be flattened and bent down over the chest piece, then the two are made fast by a rivet. The ends of the chest piece are flattened out and a hole $\frac{5}{8}$ of an inch in diameter drilled for fastening the shoulder bands. The upright and chest piece are at right angles to each other. The thigh band is made of strap iron of the size of the chest band and fastened to it an inch below the bend, in such a way that the inner portion of the band is 1 to 2 inches shorter than the outer. The calf band of strap iron also is fastened to the bottom of the upright by a single rivet. The part of the splint next to the patient is covered with thick felt, and a covering of sheep-skin may be stretched on wet.

FIG. 182.—Bradford's abduction hip splint.

The final fitting of the splint to the child is done with wrenches until the bands fit closely to the leg and chest. The leg is bandaged to the splint and suspender straps pass from the top of the upright over the shoulders to the holes in the ends of the chest piece.

The Thomas hip splint gives fixation without traction. When properly applied, it gives the best sort of fixation. It should be worn continuously for months and only removed at long intervals by the

surgeon with plenty of assistance, so that the hip is prevented from making the slightest possible movement during removal and until it is reapplied and secured. Weight-bearing on the effected limb is prohibited, but except during exacerbations the child may walk on crutches, with a high sole under the well foot.

**The Thomas hip splint for double hip disease** is similarly made and fitted, but the uprights are attached to a single chest band and are connected at their lower extremities by an iron rod of suitable length to keep the feet about 12 inches apart. It should be most carefully padded as it is used to secure rest in the recumbent posture.

FIG. 183. Cheap tubular hip splint made of gas pipe.

### TUBULAR HIP SPLINTS.

For little children under 5 years of age the writer uses a traction splint with an upright of steel tubing, because it is stiffer and lighter than a small steel rod. The upright consists of a piece of steel tubing $\frac{7}{16}$ or $\frac{1}{2}$ inch in diameter into the upper part of which is brazed a forging similar to the flattened end on the upper part of the upright of a traction splint; into the lower end slides a rod which below is forged into a light foot piece while the upper portion of the rod, for 6 inches, is threaded and carries two nuts. The rod sliding in the tube almost fills it; a slot in the tube permits fastening a pin into the rod to prevent the foot piece from turning around. Straps for the foot piece, the posterior half bands, and the thigh bands are suitably attached, and the waist band does not differ from that of the ordinary traction splint. By strapping the leather straps of the foot piece into buckles on the leg extension, and turning the nuts, the foot piece is protruded from the tube and exerts traction against the counter-extension of the perineal bands.

Tubular splints have been made by other surgeons in various ways.

*The Gas Pipe Splint.*—A very cheap traction splint was made by Wilson out of $\frac{3}{8}$ inch steel gas pipe. The lower six inches are flattened in a vise and given the proper bends for a foot piece; the top is screwed into a Tee bearing the anterior and posterior arms of the waist band, also made of flattened tubing. Its cheapness commends it, but it is not durable.

## THE THOMAS KNEE SPLINT.

The Thomas knee splint is a perineal crutch; it consists of a rigid ring for the top of the crutch and two lateral uprights joined together in a foot piece.

The ring is made of round steel wire, No. 5 gauge for children; No. 3 for adults; with the ends brazed together or welded. The shape is an irregular ovoid and approaches a right-angled triangle. The front is flat, the back bulging; it slopes down both from within outward and from before backward. It is fastened to the inner upright by brazing, at an angle of 135°. The anterior surface of the ring is flat to conform to the groin; the posterior part expands to support the tuber ischii and conform to the thickness of the buttock. The posterior part is made lower than the anterior to enable the patient to rest the tuberosity of the ischium comfortably on the ring. The measurement for the ring is the oblique circumference of the thigh at the perineum taken one inch below and parallel to the fold of the groin, to which $1\frac{1}{4}$ inches should be added to allow for the padding.

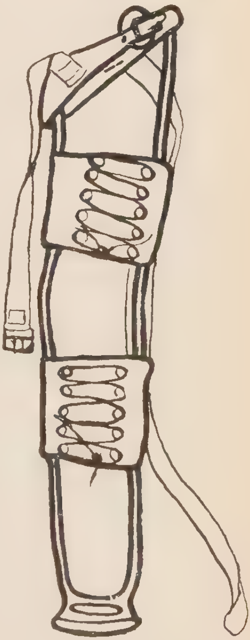

FIG. 184.—Thomas' knee splint.

The uprights are made of round steel wire; No. 1. for an adult; No. 2, 3, or 4 gauge for a child. They are secured to the ring by brazing. The outer rod is fastened to the ring slightly

farther back. The bottom of the rod should be 2 or 2½ inches below the sole of the bare foot. As originally made, the inside upright curved around under the foot to become the outside upright, but for walking, foot plates are better; they are made of various patterns and are brazed on. A large iron washer ¼ of an inch thick attached to the uprights makes an excellent foot piece; if shod with a piece of sole leather. The length of the inner upright is the distance from the tuberosity of the ischium to the sole of the foot at right angles to the leg with 3 inches added. The width at the knee and ankle should be given the workman as well as the size of the ring, and a tracing of the leg. The ring is padded with felting ½ inch thick at the outer part and from 1 to 1¼ inches thick on the inner and posterior sides; the felt is tightly covered with thin calf or tanned sheep-skin applied wet and sewed after the manner of harness makers along the lower border of the ring where the seam cannot chafe the skin. Various methods of securing the leg in the splint are in use. Two pieces of leather, 4-6 inches wide, sewed to the outer upright, and loosely surrounding the inner and the limb are used to lace the thigh and leg into position; or, with a broad strap behind knee and ankle the leg is secured to the splint by a bandage; and where the knee is slightly flexed a leather knee cap with straps and buckles at the four corners may exert corrective pressure backward.

Thomas used to bandage the splint tightly behind the calf of the leg with a roller bandage, but above the knee he tied his bandage to one upright, carried it over the thigh, under the other upright, over the thigh, under the upright, etc., until at the knee the bandage exerted considerable corrective force to extend the joint. Broad leathers attached to one upright with lacings and hooks have already been spoken of; they are best made from paper patterns cut to suit each case. The leather knee cap should have a hole to avoid pressing on the patella and extend an inch above and below it; at each corner is a buckle and strap to encircle the upright and return to the buckle. If the knee hyperextends a 3–4 inch leather strap is sewed across between the uprights and the knee cap presses the knee back on to it.

## THOMAS'S CALIPER SPLINT.

For those who can be allowed to walk on the toes, the caliper splint may be used. Those who have reached this stage may have their old knee splint converted into a caliper splint by sawing off the foot piece from the uprights and bending the last inch sharply inward at a right angle. It is best to apply the unfinished splint in its proper position and mark upon the uprights the place for bending, which should be such that the heel is kept an inch above the heel of the boot.

The splint consists of the ring and uprights of the Thomas knee splint which are bent below at right angles to fit in a steel tube in the heel of the boot. The bends should be an inch long, and a leather strap around the ankle prevents the uprights slipping out from the tube. Either a knee cap may be employed, or wide thigh and calf leather lacings. Where the heel strikes against the back of the boot it sometimes excoriates, in which cases a triangular piece of leather should be put in the back of the shoe for the heel to play on, and it is sometimes necessary to slit the back seam just above the counter for a short distance. The splint may be nickeled, blued, or japanned.

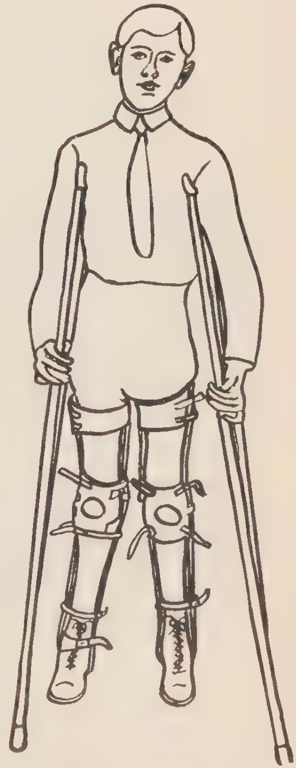

FIG. 185.—Thomas' caliper splints for infantile paralysis.

A similar splint is often used for infantile paralysis to keep weak knees from bending; but the Thomas ring is unnecessary, and a posterior half band of steel, $1\frac{1}{2}$ inches wide, is substituted, the splint ending below the gluteal fold. Where toe-drop or calcanous

interferes with walking an ear, three-quarters of an inch long by a quarter wide, is left in cutting off the steel tube, which is turned upward after putting it into the boot heel so as to strike the upright and stop further motion. For toe-drop it is placed behind, for toe-rise in front of the upright.

## FIXATION ANKLE SPLINT.

This splint, used for fixation and protection of the ankle-joint after operations, arthrodesis, and tendon transference, consists of two uprights, a foot piece, and a posterior calf band. For the

FIG. 186.—Fixation ankle splint.

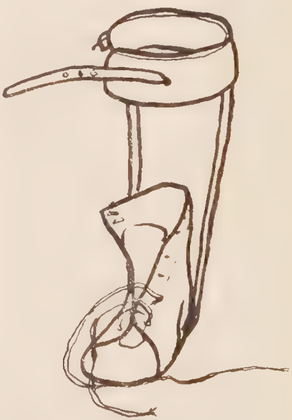

FIG. 187.—Same splint to show leathers.

uprights, one continuous piece of steel may be used, $\frac{5}{8}$ to $\frac{3}{4}$ of an inch wide by $\frac{1}{8}$ thick, attached to the foot piece with a right-angled bend on either side; these bands must be shaped sufficiently not to touch the foot on either side; the malleoli especially must not touch them. They are riveted at the top to a posterior calf band, curved to fit the posterior half of the calf, made of No. 16–17 steel, an inch wide.

*The foot piece* is a plate of sheet steel of No. 14–16 gauge forged

roughly to the shape of the sole of the foot from the toes to the heel. It should be $\frac{1}{4}$ of an inch narrower on each side than the whole width of the foot and should stop $\frac{1}{2}$ inch in front of the back of the os calcis and should be riveted on top of the horizontal part connecting the two uprights.

*Leathers and Buckles.*—The calf band is padded with felt and covered with leather ending in a strap to buckle around the front of the leg. A piece of soft leather, cut by pattern like the upper of a low shoe, covers the foot from behind the metatarso-phalangeal to the ankle joints, leaving the point of the heel uncovered; it is riveted by its sole to the sole plate. The two flaps meet over the top of the foot and lace down the middle with a fly like the tongue of shoe to prevent pressure from the lacings. The posterior part of this foot leather is sewed by a vertical seam behind so to fit snugly over the tendo-Achillis. The sole piece of the brace may be made lighter if the weight is not to rest upon it. It is often used with a Thomas knee splint to maintain a correct position of the ankle, which otherwise might get stiff in the position of toe-drop.

## KNOCK-KNEE IRONS.

**The knock-knee brace** consists of an upright and a foot piece.

*The upright* is made of malleable steel, tempered, $\frac{1}{2}$ inch wide and $\frac{1}{16}$ of an inch thick, and extends vertically from a point opposite the ankle-joint to the top of the trochanter, where it bends upward and backward to end just below the posterior superior spine of the ilium. The bottom of the upright is flattened and enlarged and has a $\frac{1}{4}$ inch hole, for the spindle of the ankle-joint.

*The base piece* is divided by a right-angled bend into a sole part and a vertical piece. The sole part is a triangular piece of the same steel nearly as wide as the boot heel and terminating in front in a broad rounded point. It should be $1\frac{3}{4}$ inches long and a little less wide than the shoe. At its outer border the verticle side piece begins as an arm of the same size and width as the lower end of the upright; to which it is connected by a joint opposite the child's ankle. It is curved out to avoid the ankle and a pad, the

size of a twenty-five cent piece covered with felt, is sometimes added to protect the outer malleolus from pressure. At the top of the upright where it presses on the outside of the thigh, a thin steel round pad should be added to distribute pressure. At the posterior extremity of the arm, at the top of the splint, is a strap which passes round the waist and buckles at the bend on the top of the upright. Double buckles riveted to the upright at suitable places attach the straps from the leather pad which exerts pressure over the inner side of the knee. This pad should extend from the middle of the calf to the middle of the thigh and be wide enough to half encircle the limb. On its borders are leather straps, four or five on a side to buckle to splint. The efficiency may be much improved by riveting to the upright a short posterior calf band and a similar thigh band and connecting them with a flat steel rod. This affords, with leather straps, fixation for the knee like a ham splint and prevents bending that joint; these bands should be only one-third as long as the circumference of the limb.

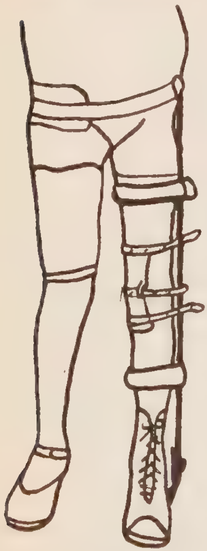

FIG. 188.—Knock-knee iron applied.

The measurement and weight of material are for a child three or four years old. After that age it is useless to try to correct knock-knee by irons.

## BOW-LEG IRONS.

Bow-leg irons likewise consist of an upright and a foot piece. They are used for lateral bowings. Here the upright runs on the inner instead of the outer side of the leg, from the inner malleolus to just below the perineum, where it curves forward and outward to form a long anterior arm. The anterior arm is convex forward to fit the curve of the upper thigh, ending at the trochanter. Half inch steel, No. 15 gauge, is sufficiently strong for the upright. It is slightly widened and is jointed below to a foot piece like the one

for knock-knee, excepting that the joint comes on the inner side of the foot where a broad pad covered with felt and leather prevents chafing. Three or four pairs of buckles, facing opposite ways, are riveted to the upright opposite the place of lateral bowing. On the outer side of the leg is a pad with straps like the one used for knock-knee. The curved anterior arm is covered with leather and is protected by a circular pad, to distribute pressure on the thigh at the angle where it begins. Two straps from this point encircle the thigh, one coming around and buckling into its own starting point, the other buckling to the outer end of the arm. The arrangement of these straps is modified when a pair of irons is used.

FIG. 169.—Dane's brace for bow-leg.

As the internal malleolus is so prominent the vertical part of the base piece should have an offset of $\frac{3}{8}$ of an inch.

### DANE BOW-LEG IRON: ANTERO-POSTERIOR BOW-LEG BRACE.

This splint aims to prevent bending of the knee and consequent loosening of the corrective straps. The uprights are made of sheet steel, No. 16 gauge, $\frac{5}{8}$ of an inch wide; the anterior one extends from a point an inch above the bend of the ankle to the middle of the thigh or higher, the posterior one from corresponding points on the back of the leg. They are fastened above to a thigh band of flat steel, an inch wide, covering the inner half of the thigh, and at the bottom to an ankle band of irregular shape cut out of sheet steel from a pattern, which serves to connect the lower ends of the uprights with the ankle-joint. This shape is seen in the accompanying drawing. It should clear the foot at all points, but, as under pressure of the lacings the foot may bend over to it, it is padded with leather and felt. It is perforated with a quarter inch hole for the spindle of the ankle-joint.

The foot piece is similar to that already described. Two flaps of leather one on each upright are riveted to the surface nearest the

skin, from the bottom to the knee or above it if the knee bows out. They are cut wide enough to overlap each other slightly around the outer side of the leg and finished with a row of eyelets or lacing hooklets which must be far enough apart to make it impossible to approximate them by tight lacing. The thigh band is protected with felt or leather and a strap and buckle secures it in place.

## SPLINTS FOR INFANTILE PARALYSIS.

**The Caliper Splint.**—This has already been spoken of on page 375. It has been found that toe-drop or paralytic calcaneus may be relieved by the modified use of this splint. By turning up from the edge of the steel tubing as it emerges from the boot heel, a small piece to strike against the upright of the splint, behind it or in front, further ankle motion is prevented, if it is made to strike behind the upright it prevents toe-drop—if in front, it prevents toe-raising. When there is only a paralytic toe-drop or a talipes calcaneus the uprights may end in a calf band and knee action be unrestrained.

**Apparatus for Infantile Paralysis.**—To make paralytics walk, it is often necessary that the brace should have a rigid foot piece, and it is more convenient if the knee can be flexed in sitting. Infantile apparatus, therefore, should consist of a foot piece, two uprights, posterior bands, when necessary a knee-joint, and for some the outer upright has to extend above the hip with a joint above the trochanter and a broad leather belt, or the splints may be attached to a leather jacket. The form of foot piece varies with the distortion and a club-foot shoe or a varus shoe should be attached to the upright on the proper side of the foot. If no distortion of the foot be present, both uprights should be jointed at the ankle but the foot piece in other respects resembles that of an ankle splint. The external upright should reach from the malleolus to a point over the trochanter.

The splint should be of steel, at least $\frac{5}{8}$ of an inch wide and $\frac{1}{12}$ of an inch thick, curved to follow the outline of the leg, leaving free space enough so that the outer malleolus and the outer surface of the knee-joint cannot touch it, but the rest of the leg may touch it. The inner

upright, made in the same way, reaches from the inner malleolus to an inch below the perineum. Both uprights should be jointed at the knee—the joints moving in parallel planes. The outer joint should be furnished with a drop catch or a spring catch, so that it can be loosened when the patient sits. The thigh band should be 3 inches wide on the top at its outer end, and $1\frac{3}{4}$ inches at its inner. It fits the back of the thigh, is riveted to the top of the uprights, and it is made of No. 15 gauge steel. The other connecting bands should be $1\frac{1}{8}$ inches wide, of the same material, and should encircle the lower third of the thigh and the upper third of the calf. A knee cap and broad leathers with lacings cover the limb except at the knee, from the top of the splint to a point 2 inches above the malleoli.

The illustration shows the drop catch and a self-locking spring catch. These catches are always applied to the knee-joint on the external upright because it is easier to adjust it there. Lacing hooklets placed at $\frac{1}{2}$ inch intervals are convenient fastenngs.

The foot piece we said varied to suit deformity. If the form of foot piece indicated to maintain a correct walking position demands one instead of two uprights, one may be cut off at the lower border of the calf band, or to make it more solid it may be bent at a right angle on the flat and itself extended as a posterior calf band and attached to the other upright by rivets. The finish of these splints should be nickel or bluing.

**No definite rules for infantile splints** can be made, the splint must fit the condition and there are many different conditions in paralytics. The studentof orthopedics must design a splint for the indications presented; sometimes paralysis is extensive and a double apparatus is indicated like the one described, only it has to be attached to a jacket by jointed hip pieces; sometimes a simple caliper with a stop piece to prevent toe-drop is all one needs, or even a short caliper and stop.

Less extensive forms of infantile paralysis, where the knee action is normal, may require the support of one of the many forms of talipes apparatus as the club-foot shoe for equino-varus deformity, the valgus steel shoe, the steel shoe for simple equinus and for simple calcaneus.

## THE VALGUS SHOE.

This apparatus is the reverse of that for equino-varus. It consists of a sole plate, an angle iron, an upright and a calf band.

*The sole plate* is cut like a stiff paper or leather-board pattern made from the patient by the orthopedist; it is made of No. 16 gauge sheet steel. A long flange is turned up at a right angle to follow the outer border of foot; the inner side of sole is raised up to lift the arch of the foot as much as is indicated on the pattern. The sole plate extends from the cleft under the toes to a finger's breadth in front of the tip of the heel, and the side flange from the head of the fifth metatarsal to a finger's breadth in front of the rear end of os calcis. It is bored with suitable holes for rivets to attach the angle piece, the leather lining, straps and buckles.

*The angle piece* is of machine steel, No. 9 or 10 gauge, $\frac{7}{8}$ of an inch wide, bent at a right angle; the sole part is riveted to the plate and ends at its inner border conforming to its shape; the vertical part has an offset to keep it away from the outer malleolus and a quarter-inch hole for the spindle of the ankle joint.

*The upright*, $\frac{5}{8}$ of an inch wide and $\frac{1}{8}$ inch thick, is broadened at the bottom, bored with $\frac{1}{4}$ inch hole for the spindle of the ankle-joint (the distance from the sole to the center of the internal malleolus determines the height at which this should be placed); the upright ends 2 inches below the head of the fibula where it is riveted to a calf band.

*The calf band* is of No. 17 sheet steel, $1\frac{1}{4}$ inches wide and long enough to encircle the posterior half of the leg; it is riveted to the inner surface of the upright so that it projects $\frac{1}{2}$ inch in front of it. It is leather lined and has a wide strap and buckle. To the inner edge of the sole plate is there riveted, below the internal malleolus, a T strap of jacket leather cut by a separate paper pattern; the top of the T should be an inch above the tip of the malleolus; the horizontal arms must be high enough to avoid pressing on the tendons at the annular ligament; one arm ends in a buckle, the other straps into and should be of such length that the buckle will lie on the upright so as not to press on the skin.

Webbing straps, one from the hind end of the flange, and one from the inner border of the sole plate behind the head of the first metatarsal, are made to fasten in the buckles on the flange.

## SHOE FOR TALIPES EQUINUS.

This apparatus is like the one for fixation of the ankle-joint except that the uprights are stop-jointed at the ankle. The sole plate is sometimes riveted to the sole of the shoe, oftener the apparatus is removable and worn outside the stocking. In order to prevent plantar flexion stop joints are used, but as at first it may not be possible to stop it entirely the pin should be placed slightly in front of where it should go—after stretching the foot by the use of this apparatus for one or two months, it may be reset in its proper place. The top of the uprights end in a posterior half band, of 17 gauge sheet steel, extending half way round the calf of the leg. If talipes equinus exists with varus, the shoe, see p. 384, is applicable; when it is a simple equinus a double upright apparatus is indicated; and when, in rare cases, valgus is present with equinus, the valgus shoe should be used with a stop in the ankle-joint.

## APPARATUS FOR TALIPES CALCANEUS.

Talipes calcaneus may be treated by apparatus similar to that just described for equinus, but with the stop reversed so as to prevent toe-raising instead of toe-drop.

## THE CLUB-FOOT SHOE.

This splint is a modification of the Taylor club-foot shoe. It consists of a sole plate, a base piece, an upright, and a calf band.

*The sole plate* is cut from a piece of sheet steel, No. 16 or 18 gauge, which is shaped from a pattern of stiff paper or card-board marked and cut by the orthopedist to fit the weight-bearing part of the foot, with two flanges turned up on the side to furnish pressure on the inner side of os calcis, and on the head of first metatarsal and great toe, the intervening portion between the flanges being cut away for lightness. The sole plate extends from ½ inch in front

of the posterior border of the heel to the cleft or the tips of toes. The forward side flange should extend from the proximal end of the head of the first metatarsal to the interphalangeal joint of the great toe; the posterior side flange presses on the side of the os calcis below and behind the internal malleolus, rising to cover the posterior superior corner of os calcis. The plate in front is the width of the ball of the foot compressed, and behind it is almost

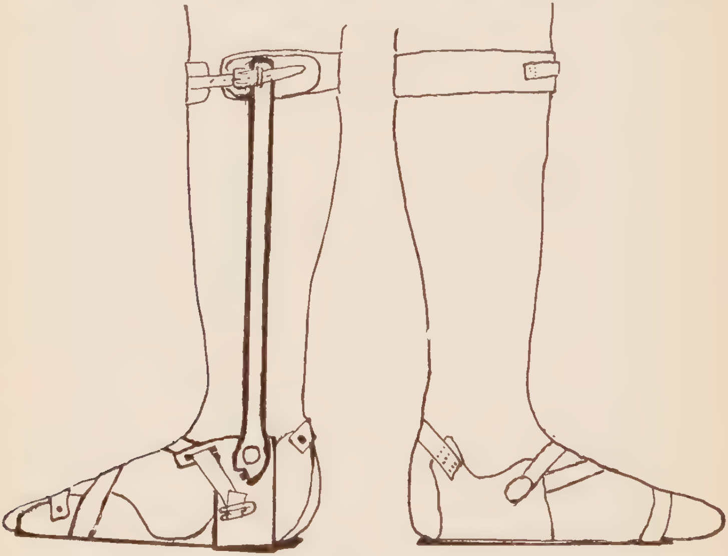

FIG. 190. -Inner and outside aspects of right foot wearing club-foot shoe.

as narrow as the width of the os calcis. The pattern should be made and fitted to the foot with care, it is cut out of cardboard or leather-board with flanges properly turned up.

*A base or angle piece* connects the foot plate with the upright at the ankle-joint. The angle divides it into two parts at right angles to each other; it is of steel of No. 10 or 12 gauge, and $\frac{3}{4}$ of an inch wide, the posterior part is forged to fit the sole plate to which it is fastened by three steel rivets. The side portion at right angles to the sole plate rises a half inch above the internal malleolus with an

offsetting bend to give plenty of room so that the malleolus cannot possibly touch it; $\frac{1}{2}$ inch below the top it is perforated in the center by a quarter inch hole for the spindle of the ankle-joint.

*The upright* is a flat steel bar $\frac{1}{2}$ to $\frac{5}{8}$ of an inch wide and $\frac{3}{16}$ of an inch thick flattened at the lower end where it is perforated by the spindle of the ankle-joint; it ends at a point below the insertion of the inner hamstrings where it bears a small plate of metal covered with leather and a calf strap. In order to prevent toe-drop the widened end of this upright is filed into the shape shown in the adjoining figure, and a pin or stop is fastened in the base piece.

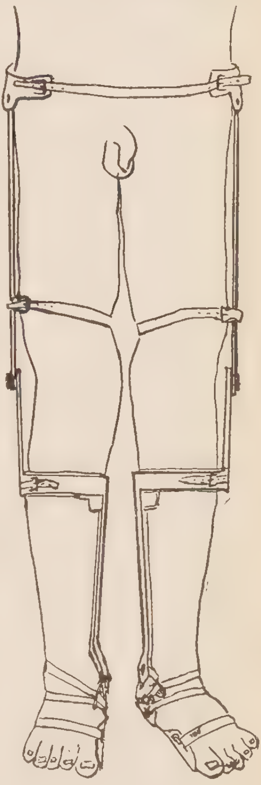

FIG. 191.—Club-foot shoes prolonged to waist.

*The sole plate* is covered with thin calfskin, strong webbing straps secure the foot to it, which exert pressure on the outer side of the foot over the calcaneo-cuboid joint, and hold the external malleolus firmly to the inner side of the base piece. Various schemes are used to obtain strap pressure at different points of the foot. One method is to attach to the outer side of the sole plate, opposite the calcis, a triangular bit of leather on which a small metal ring is secured by stitching. A strap from the upper corner of the angle or base piece passes behind the tendo-Achillis, over the external malleolus, through the metal ring; then turns inward over the top of the foot and is attached to a buckle near the ankle-joint. The front of the foot is secured by a single strap riveted to the sole plate which passes behind the head of the fifth metatarsal, inward and forward, fastens in a small buckle on the inner side of the front flange.

**The Club-foot Shoe for Talipes Varus.**—For the correction of

talipes varus, especially in babies, it is necessary in order to make them toe-out, to prolong the upright, carrying it across in front of the shin to the outer side of the leg, thence straight upward to a knee-joint, upward again to the trochanter, where a metal band is attached to a tee piece by a movable joint at the hip and belted around the waist. This merely serves to make them toe-out.

## FLAT-FOOT PLATES.

These are made of many different patterns by different orthopedic surgeons and as they are used to accomplish different objects, the shape is varied for different patients. The surgeon knows what he is to accomplish and uses his good mechanical judgment. The best guide is to have the patient stand on a low table while the surgeon tries with his hand to learn in what way the applied force corrects best; the thrust upward or sideways of the plate is thus determined. Upward pressure may be made under the front of the os calcis and the sustentaculum tali; under the scaphoid and cuneiforms; or behind the heads of the second and third metatarsals; sideways thrust is obtained by raising the inner edge of the plate, which is made to slope to the outer side; any steep slope makes the foot slide which can be prevented by turning up one or two flanges on the outer border, or a high inside border and an outer flange at the heel may hold the os calcis while the front of the foot receives a side thrust from the sloping of the plate. Abduction of the front of the foot often demands two outer flanges, one opposite the os calcis and the other against the shaft of the fifth metatarsal and an inner border extending high over the scaphoid, for if the edge should be close to the tubercle of the scaphoid it will hurt. Ordinarily the entire width of the sole is to be supported. The front of the plate should end behind the sesamoid bones of the great toe and the posterior edge cover the weight-bearing part of the heel. For flexible feet a shorter plate is used—for rigid ones a longer one.

Steel plates should be tried on and fitted with wrenches before tempering; and it is a good plan if in doubt to have them worn for a day so that the places which hurt may develop.

Among many defects which may be present in flat foot plates they

should not, at the outer border, overhang the shank of the boot; nor rock, that is both the front and back edges should be everywhere in contact with the sole; when applied to the relaxed foot the edges should not spring off from it. When the patient stands on the plate he should not feel a sharp hump or ridge, but he should feel an even, well-distributed pressure; the edges should not press in or hurt. If there are painful points on the foot, the plate should be depressed or fashioned to avoid them, and there is much to think of, both when carving the cast and when the plate is tried on;—a little experience is the best teacher.

When the cast is prepared it is marked by the surgeon with the outline of the proposed plate. A paper pattern is cut from this and used to transfer the outline of the plate to the sheet steel. This should be of Nos. 16 to 19 gauge according to the patient's weight. It is heated to bright cherry red and shaped to the carved plaster cast by the blacksmith; rough shaping and turning up flanges is done on the anvil—finer work on the cast or on a lead anvil. The rough edges are filed off or ground and the plate is ready to try on. Afterward it is tempered and nickel plated or blued. It is sometimes covered with leather, thin sheep-skin, or dog skin. When a plate tends to slip in the boot, a thin leather insole cut like the insole of the boot may be fastened to its lower surface.

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